Assessment comparing Meat Production Processes in selected countries with a focus on potential Consumer Exposure to Foodborne Disease

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Executive summary

This is a report on a study comparing international food production processes and the prevalence of a number of microorganisms. The study was designed to look at the collection of information and data from various country / meat combinations (including UK), on the production of meat and poultry meat. This follows an initial feasibility study which considered these aspects in relation to poultry only and four countries. The results of the feasibility study are incorporated within this report.

The study demonstrated that data collection could be challenging, due to the variance in data styles and types available in different countries and the language related issues in non-English speaking areas, particularly when reviewing in-country legislation and data used for local purposes. As described later, another challenge relates to the way different countries undertake surveys, including methods of sampling, sample handling and testing methodologies which can be different.

Whilst countries have control plans for their processes, the way those plans operate is different and can be difficult to compare. Data is collected in various ways, sampling and testing are done differently and data presented in a multitude of formats. This does not necessarily mean that control plans are less effective. Furthermore, if meat is intended for export to the UK it must meet the UK’s import requirements.

Attempts have been made to standardise, as far as possible, the varied information, but hidden within some data, variation will exist. A summary of the overall microbial prevalence reports identified is provided along with individual country reports. A spreadsheet has been produced alongside this report. This contains key questions answered within this document, each country/meat combination has a short, binary or quantitative answer. A PivotTable has been developed as part of the sheet which allows the user to model trade scenarios and compare side by side data from different regions. Instructions on how this can be used are within the spreadsheet.

This report primarily considered steps involved in the production of meat and poultry in relation to the processing plant. The differences in prevalence at the farm level are covered where possible in the microbiological section. Biosecurity is an important factor for bird, animal and human health and has been considered in this report. Issues relating to animal welfare were not considered in detail unless they affected food safety.

In relation to poultry and meat processing, the basic procedures are largely the same in all countries studied. These steps include, but are not limited to, on-farm practices, animal catching and transport, ante-mortem inspection, slaughter, evisceration, post-mortem inspection, chilling, dressing and packing. Intervention steps adopted by countries to ensure food safety were considered. This included aspects such as the use of chemical treatments, chilling, inspection and the setting of microbiological criteria to limit the level of microorganisms on poultry or meat products and/or to monitor the effectiveness of process controls as well as the approval of establishments. These aspects are often addressed in national legislation. Which requirements are set, how they are framed in legislation, how detailed they are and how they are implemented and monitored was found to vary between countries.

Countries within the European Union largely had identical processing procedures due to the harmonised legislation present. The UK also had a similar set of procedures in place having only recently exited from the EU. Ante and post-mortem inspection procedures were overall the same, as well as guidelines for chilling. Small differences were found in the level of detail or standards depending on the country, for example the UK had clearer biosecurity protocols than some other EU member states such as Poland.

Non-EU member state Ukraine is an EU exporter and appeared to comply with requirements. A small number of very large processors dominate the sector and therefore information is less available. Most information was gained through EU audit data.

USA and Canada had largely the same inspection protocols as the EU, but the key differences were in chilling times and temperatures, as well as permitted chemicals during carcass washing. Canada has similar chilling requirements to the UK, whereas USA does not prescribe any specific times or temperatures. Both USA and Canada permit chemicals in washing water for carcass and cuts. Growth promoters are also permitted in the USA.

Australia and New Zealand show slight differences to UK/EU in terms of chilling, where they have developed a scoring system based on the data collected from chilling processes. Their inspection protocols appear to be similar, and the use of growth promoters is permitted in Australia.

South American nations, Brazil, Chile and Uruguay, are quite different in their approach and the amount of information available. Little to no information was found on biosecurity, but most inspection duties are carried out by the competent authority. Pathogen reduction treatments were permitted on carcasses.

Botswana and Namibia showed two different approaches due to their ongoing control of food and mouth disease. The northern regions of each country were not permitted to export to the EU due to existing cases of the disease, whereas the southern regions had more robust biosecurity controls and therefore were able to export. Little to no information could be found on control relates to chilling or pathogen reduction treatments, but the small amount of EU approved facilities appeared to adopt the EU requirements for this.

Limited information was available for India, but inspection procedures appeared to be similar to the UK/EU. Information found on chilling and other intervention steps was limited and out of date.

When taking samples, different countries use different sampling techniques to attempt to recover microorganisms from carcasses. In some cases, swabbing is used, in others excision sampling (cutting away a surface sample of the carcass), in some poultry sampling whole bird rinses are used. Using the same sample type continuously allows a direct comparability of results. Different sampling methods may give some variation in result, although for testing for the presence of a microorganism, swabbing and excision will give broadly similar results (Pepperell *et al*. 2005).

In the UK and EU countries approaches to sampling and the test methods used will be well harmonised. Sampling will predominantly use swabbing for carcass samples and 10g or 25g of meat for meat cuts and retail sample tests. Poultry sampling of whole birds will be via taking neck skin samples. Testing will use International Standards Organisation (ISO) methods or methods validated against ISO methods. In the USA approaches are different. Whilst swabbing may still be used for carcasses, meat cuts and retail samples may require 375g samples sizes (depending on the organism being analysed) and methods will be based on those required by the US FDA or USDA. Testing of poultry carcasses will often be via whole bird rinses. Other countries within the American continent often use sampling and testing methods based on those from the

USA, often because this helps in export of food into the USA. It does appear that some South American countries will tailor their testing approaches depending on export markets, adopting USA like systems for meats being exported to the USA, and EU like systems for meats likely to be exported to the EU. Australia and New Zealand have well defined systems for sampling and testing usually with the potential to use ISO or USA methodologies.

Despite the variation, an attempt was made to collate as similar information as possible for all countries from the most recently available data obtained from raw meat poultry and meat carcasses (sometimes at slaughter establishments, sometimes at retail) from official sources. *Salmonella* data was expressed as presence / absence of the organism (but note that the samples may be from different sources/sites on the bird). Generally, standard reference methods were used which, although different, are probably very similar in their ability to recover the organism. *Campylobacter* data is slightly more problematic: it will have the same sampling issues as discussed with *Salmonella* testing. However, test methodology is changing with many countries reassessing a requirement to detect the organism and moving to an enumerative approach with defined enumeration criteria for acceptance or rejection; this is due to *Campylobacter* being present on a large proportion of poultry carcasses in most countries. This means a criterion of absence would not enable producers to show improvements in hygiene. A criterion based on counting numbers does allow improvements to be observed over time. Similarly, the methods of analysis for Shiga toxin-producing *Escherichia coli* (STEC) have also developed. Earlier studies would have identified only O157 serotype whilst more recent studies would provide more detailed analysis to identify Shiga toxin genes and serotype.

It was difficult to obtain information on the use of antimicrobials for most countries, and data on antimicrobial resistance (AMR) is often limited and comparisons are hampered by a lack of consistency in methods for determining AMR. Therefore, consideration was given to whether or not a control plan for antimicrobials is present, if monitoring reports are available and whether there are programmes in place to reduce the level of use.

The overall structure of the report is as described in section 3.

Glossary

Abbreviation	Description
ABPA	Brazilian Association of Animal Protein
AHA	Animal Health Australia
AHDB	The Agriculture and Horticulture Development Board
AMR	Antimicrobial resistance
AV	Assistant Veterinarian
cfu	colony forming unit
CA	Competent Authority
CCA	Central Competent Authority
Codex	Codex Alimentarius
Defra	Department for Environment, Food and Rural Affairs
DIPOA	Department for food of animal origin
DVO	District Veterinary Office
EC	European Commission
EMA	European Medicines Agency
ESBL	Extended-spectrum β-lactamases
EU	European Union
FBO	Food Business Operator
FMD	Foot and mouth disease
FSA	Food Standards Agency

FSAI	Food Safety Authority of Ireland
FSMP	Food Safety Management Plan
FSS	Food Standards Scotland
FSIS	Food Safety and Inspection Service
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis and Critical Control Point
ISO	International Organization for Standardization
MLA	Meat and Livestock Association
NL	The Netherlands
NVWA	Netherlands Food and Consumer Product Safety Authority
OA	Official Auxiliary
OV	Official Veterinarian
PCU	Population Correction Unit (i.e. 1 kg animal weight)
SAG	Agricultural Livestock Service of Chile
SIF	Federal Inspection Service
SFCR	Safe Food for Canadians Regulations
STEC	Shiga toxin-producing *Escherichia coli*
UK	United Kingdom
US or USA	United States of America
USDA	United States Department of Agriculture
VTEC	Verocytotoxigenic *Escherichia coli*

1. Aims and objectives

The aim of this project was to gain a better understanding of potential foodborne disease risk from imported food products through analysing food production practices, intervention steps and associated regulatory requirements, as well as to identify the availability of data on microbial prevalence and contamination rates in other countries. This was in the context of the UK having left the EU which may lead to shifts in trading patterns in the future. The issue of antimicrobial resistance was also considered.

The project considered various meat / country combinations and microorganisms as defined by the FSA during project scoping (see below).

The objective (and tasks) for this work was established by the FSA, namely to provide responses to the three key questions which have been identified below:

Q1 For each relevant meat type and country of interest, what are the contamination rates of food products based on sampling results of the hazards of interest? (Where relevance relates to meat type imported from a specific country).

Q2 For each meat type and country of interest combination, what are the food safety interventions and production processes used?

Q3 How do the identified food safety interventions and production processes impact on food safety?

The microorganisms considered, depending on meat type, were specified by the Food Standards Agency and included:

- *Salmonella*
- *Campylobacter*
- Shiga toxin-producing *Escherichia coli* (STEC)
- *Trichinella*

A summary of the country and meat combinations as requested by the FSA is given in Table 1. Note, after the UK, the table is ordered by continent with each country in alphabetical order.

Table 1: Country *vs* meat type (Beef, Pork, Poultry, Lamb) combinations

Country	Beef	Pork	Poultry	Lamb
UK	Yes	Yes	Yes	Yes
Denmark	No	Yes	No	No
Ireland	Yes	No	No	Yes
Netherlands	No	Yes	Yes	Yes
Poland	No	No	Yes	No
Ukraine	No	No	Yes	No
Canada	Yes	Yes	Yes	Yes
USA	Yes	Yes	Yes	Yes
Brazil	Yes	No	Yes	No
Chile	No	Yes	Yes	No
Uruguay	Yes	No	No	No
Australia	Yes	No	No	Yes
New Zealand	No	No	No	Yes
Botswana	Yes	No	No	No
Namibia	Yes	No	No	No
India	Yes	No	No	No

2. Method

This project was conducted as a desk-based study accessing publicly available information. The following methods were adopted:

2.1. Literature and website searching

Sources used encompassed the following, which were used to identify the availability of services and resources:

- Websites and publications of governmental and non-governmental organisations;
- Websites and publications of relevant trade and sector associations (websites focussed on organisations and associations based in the countries identified to be of interest);
- Scientific literature via secondary sources (scientific literature databases).

Literature searching was conducted in the English language and restricted, where possible, to information published in the last ten years, although earlier reports identified were included if applicable. Searches were conducted during Q2/3 2020. Regulatory websites were searched by native speakers of the relevant language where possible (i.e. Spanish, Portuguese) if these were not available in English.

The output of the searches was reviewed to identify items of relevance:

Where possible, the outputs from government and official sources at the national and international level were used as these typically report on larger studies, so providing a broad view, use standard methods and report in a consistent format.

Scientific literature databases utilised were Food Science and Technology Abstracts and Web of Science core collection. Search terms defined the countries, meat types and pathogens of interest.

Information from the scientific literature often referred to individual or specific situations, typically from a small number of samples or farms. which may not be representative of the country as a whole or of larger scale commercial production.

In the case of prevalence data many studies related to such aspects as flock, hide or faecal prevalence. Such studies have not been included for consideration in this project. For consistency, focus was given to prevalence studies relating to raw meat and carcasses at the slaughterhouse or at retail.

3. Results

The results of this study are reported in various ways:

Overall report document which provides

- Details of the aims and objectives
- Background information on the microorganisms considered
- Generalised production process flows – red meat and poultry
- Intervention steps
- Annexes of supporting information

Prevalence data tables collated and summarised for each microorganism *vs* country *vs* meat type and included in the overall report for:

- *Salmonella* (in all meat types)
- *Campylobacter* (in all meat types)
- STEC (in beef, lamb and pork)
- *Trichinella* (in pork)

Individual overviews per country/meat combination. Hence, where more than one meat type has been studied, each has been reported as a separate section within each country chapter. This may lead to some duplication of information, but it was felt this would enable varied comparison between different countries and meats without cross-referencing between individual chapters. Each chapter aims to include the following depending on the information availability:

- Market overview
- Production processes
- Intervention steps
- Prevalence data
- Antimicrobial resistance
- References

This report presents the information located but, in general, does not comment on its interpretation. This was a departure from the original objectives (see page 28) at the request of the Food Standards Agency.

4. Background information

4.1. Microorganisms considered

Each microorganism can be associated with different meats and has different properties which themselves help to determine the control measures and intervention steps required.

A brief description of the occurrence, properties and control measures for each is given below.

4.1.1. *Campylobacter*

Poultry is regarded as one of the most important reservoirs for C*ampylobacter* spp. They are often present in the intestines of domestic and wild animals, such as cattle, sheep, poultry, dogs, wild birds and rodents, and are shed in the faeces of these animals and are transmitted to humans by the faecal oral route (Moore *et al.*, 2005).

Campylobacter spp. grow in the 30-45°C temperature range but can survive at temperatures as low as 4°C under moist conditions. Although *Campylobacter* spp. survive well at cold temperatures, they are sensitive to heat and are readily inactivated by pasteurisation treatment or domestic cooking. Heating at 55-60°C for several minutes readily destroys *Campylobacter* spp. They are highly sensitive to loss of moisture and do not survive well on dry surfaces. Several studies have shown that *C. jejuni* is sensitive to acids such as formic, acetic, ascorbic and lactic acids (Silva *et al.*, 2011; FSAI, 2011).

4.1.2. *Salmonella*

Salmonella spp. are widely distributed in nature with a diverse range of hosts. They can colonize the intestinal tracts of vertebrates, including livestock, wildlife, domestic pets, and humans, and may also live in environments such as pond water sediment. They are spread through the faecal-oral route and through contact with contaminated water. Raw meat and poultry are recognised as being foods at particular risk of contamination (Jajere, 2019).

The minimum growth temperature is 4°C, minimum growth pH is 3.8 and the minimum growth water activity is 0.89 (Campden BRI, 2012; FDA, 2012).

4.1.3. Shiga toxin-producing *Escherichia coli* (STEC)

Escherichia coli species are found as part of the normal intestinal flora of warm-blooded animals. Their presence in a sample may indicate poor hygiene or post-process contamination.

Ruminants (cattle and sheep) are the main animal reservoirs of STEC. Most species are harmless, but some have developed more virulent properties and are associated with food borne illness. In particular this includes Shiga toxin-producing *E. coli* (STEC), which can cause severe infection. Major foodborne pathogenic STEC strains include O26, O45, O103, O111, O121, O145, O157 and O104. Toxin producing strains are also referred to by the acronyms, 'EHEC' and 'VTEC'. These are synonymous and refer to the different names for the toxin that exist in literature (‘Enterohaemorrhagic’ and ‘Verocytotoxic’).

Growth of *E. coli* can occur at temperatures ranging between 7-46°C, pH of 4.4-10.0 and a minimum water activity of 0.95. Some STEC strains are able to survive at pH 2.5-3.0 for over four hours. STECs are able to survive frozen storage at -20°C but are readily inactivated by thorough cooking (Meng *et al.*, 2012; Doyle, 1991; Kaper *et al.*, 2004).

The contaminated hide and fleece are recognised as the most significant sources for the introduction of STEC into the abattoir and animals should therefore be presented clean and dry. Hygienic hide removal and evisceration, to ensure that the carcass does not become contaminated with faecal material, should be emphasised (FSA meat industry guide; FSAI, 2010).

During processing, contamination may occur from external sources (i.e. the animal or the environment), or internal sources during slaughter and dressing operations. Good agricultural practices, good hygienic practices and good manufacturing practices should be employed throughout the production chain (Sofos & Geornaras, 2010; FSANZ, 2017).

4.1.4. *Trichinella*

Trichinella species are parasitic roundworms. The larvae of these worms, which reside in animal skeletal muscle, infect other animals or humans that consume them.

Pigs are considered the most important source. Whilst thorough cooking by the consumer is one control measure other actions are taken by commercial producers to control the presence of *Trichinella.* In the UK all breeding pigs (sows and boars) must be tested for *Trichinella*. Pigs not raised in controlled housing must also be tested before they can go into the human food chain (FSA, 2020).

4.2. Meat production processes

How animals are reared is partly defined by the geography and culture of a country. Some countries have smaller independently run farms who sell their livestock to processors, whereas in others large meat companies have integrated operations where the food business operators own farms and employ farmers to rear supplied livestock. There are also unique situations, such as in the African countries studied, where there are multiple systems in place to allow for different techniques to be accommodated.

The process of converting live animals and birds to meat for human consumption contains many steps, all of which have their own consideration towards food safety and quality.

Figures 1 and 2 below provide overall schematic process flows. Actions seen as biosecurity steps and food safety interventions have been highlighted as well as where the dirty process ends, and the clean process begins. These process flows have been based on the information collected in order to write this report as well as unpublished documents and industry knowledge. The steps are common to most if not all meat processing plants.

Figure 1: Overview of generalised poultry production flow

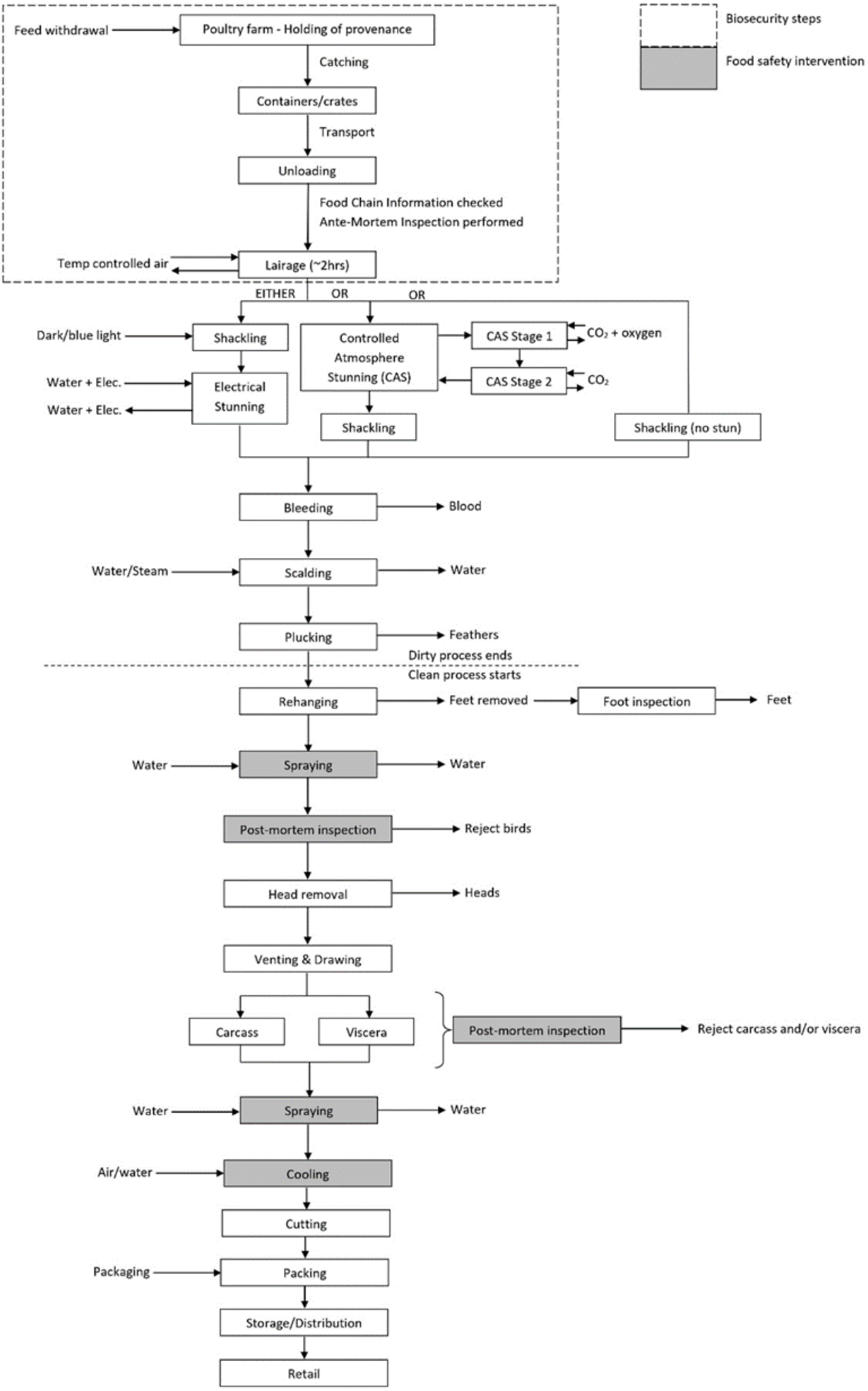

Figure 2: Overview of red meat production process flow

4.3. References for Chapter 4

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5. Intervention steps

Based on the information found to write this section, it appears there are many well established intervention steps which appear to be followed similarly in different countries. The main differences appear to be in the smaller details such as the time or temperatures required for chilling, or the permitted treatments when washing carcasses. The responsibility for inspections can vary by country, but most have a service provided by the competent authority. Where there are third-party inspections permitted these are not always used, as it does not allow businesses to import into the EU.

Further comments on the typical intervention steps are given below.

5.1. Biosecurity

Biosecurity is a set of practical measures to prevent the spread of disease on and between farms. Whilst such measures are important, specific consideration of these has not been considered in depth as part of this report which has focussed on measures post the farm gate and at the processing plant.

The availability of guidance in terms of biosecurity varies greatly across the countries studied. The content, when found, encompasses largely the same concepts but with more detail in some countries than others. The diseases focused on differ between countries, in particular where there are regions still experiencing outbreaks of animal diseases such as foot and mouth disease or avian influenza.

5.2. Carcass inspection – ante and post-mortem

Carcass inspection is intended to identify animals / carcasses which have flaws and/or are not in an acceptable condition to be further processed. Microbial contamination is unlikely to be detected in this way so separate measures are taken to tackle this such as routine swabbing of carcasses for testing. In addition, inspections also identify animals which have not been adequately cleaned and have faecal contamination.

In the UK, information from inspections is fed into a ‘trigger system’ developed by Defra which flags farms submitting birds for slaughter which are not in acceptable condition. If a farm is above a certain stocking density (33 kg/m^2) then they are required to report

cumulative daily mortality rate. Whilst similar systems may be in place in other countries, information to validate this was limited and so we were unable to confirm if these exist. Pre-slaughter information supplied by farmers is reported as part of an EU regulated 'Food Chain Information' document which is standardised for each flock. The document includes information on mortality rates, test results, medical treatments and growth conditions (Defra, 2018).

Who conducts the inspection and at what stage varies between countries. For example, in the UK, FSA/FSS-employed official veterinarians (OV) are tasked with finding defective live animals and carcasses. The Netherlands Food and Consumer Product Safety Authority (NVWA) employ veterinarians who inspect in the same fashion as the FSA. In the US, poultry flocks are inspected by the Food Safety and Inspection Service (FSIS). Public Health Veterinarians which are the US equivalent of the UK's OV carry out inspections. Brazil has a similar structure employing inspectors within the Federal Inspection Service (SIF).

Post-mortem inspection is also identified as a food safety invention (Figures 1 and 2). This is undertaken by inspectors on the production line. Their ability to undertake an effective check for flaws and the presence of faecal contamination can be affected by such factors as the speed of the processing line.

5.3. Cooling

The main differences in requirements for cooling are the temperatures specified (if any) and the time limit during which that temperature should be achieved. In the UK/EU, retained Regulation (EC) No 853/2004 specifies 4°C as the maximum temperature after cooling for poultry carcases. No time limit during which this temperature should be achieved has been applied. Processors are instead required to chill the carcasses down in a timely manner. In the US, the cooling regime for poultry is more prescriptive, again specifying 4°C but classifies carcasses into weight bands which require different times to cool as indicated in

Table 2 (James, 2006). Other countries operate slightly different regimes. For example, Brazil does not specify cooling times but has a maximum temperature of 7°C following cooling (Bailone *et al.*, 2016).

Table 2: US cooling regime

Weight of carcass (lbs)	Weight of carcass (kg)	Time to reach 40°F (4.4°C)
< 4	< 1.8	4 hrs
4 - 8	1.8 - 3.6	6 hrs
> 8	> 3.6	8 hrs

Source: James, 2006

Whilst specific details of the chilling methods used were not identified, in general a variety of methods can be used for chilling including ice-water immersion or cold air flow. There is continued discussion as to whether immersion or air chilling is more suitable. One consideration is whether immersion chilling may enable microorganisms to transfer from one carcass to another more easily than through the air. Some countries also permit the use of chemicals in the cooling water whilst others do not (Guastalli *et al.*, 2016).

5.4. Carcass washing / use of chemical treatments

The main differences identified between countries are which substances, if any, are permitted for removing surface contamination from carcasses, and how and when these steps are undertaken.

In the UK/EU, carcass washing is only permitted using potable water or clean water (or lactic acid in the case of bovine carcasses). Recycled hot water may also be used for carcases of domestic ungulates and farmed game. However, in other countries certain chemicals are permitted in the wash water. A recently published FSA study (Antic, 2020) found that washing with water was the least effective treatment on bovine carcasses but using multiple thermal or chemical treatments together can give significant log reductions in both aerobic colony counts and *Enterobacteriaceae*.

As displayed in Figures 1 and 2, the washing steps can be implemented several times throughout the process. This may be on the live animal’s hide, after de-hiding and evisceration and pre- or post-chilling.

5.5. Hygiene requirements

Hygiene to prevent cross-contamination is an important requirement. Most countries require establishments to be registered; that the buildings are of appropriate construction and have adequate facilities; that the personnel follow hygienic practices and that there is a HACCP-based plan in place.

5.6. Food safety and control system

The requirements for intervention methods are typically defined by legislation. The specific details of the legislative structure for each country are not provided in this report although an overview of the regulatory oversight is provided in Annex 2.

5.6.1. Microbiological criteria

Microbiological criteria for a variety of microorganisms and product combinations have been established and are typically regulated by legislation in most countries. Further details are available in the individual country / meat chapters. Requirements may vary per meat type. In addition to complying with national requirements producers will also need to comply with the requirements of the importing country. In the case of Namibia, no national microbiological criteria were identified, and it would appear that the requirements of the importing country are applied.

For those countries that are members of the European Union, Commission Regulation (EC) No 2073/2005 applies to the microbiological criteria for various meat types and poultry meat.

5.7. Prevalence and contamination rates

Prevalence data for different countries relies on the particular methodology chosen to detect the organism in question. Different countries use different methods for both sampling of foods and collection of samples. It is also clear that on occasion different methods are used for detection or enumeration of the key organisms. Microbiological methods used should be confirmed using appropriate validation studies and certification

(e.g. AOAC, MicroVal) if different to the standard ISO method. This information is not always given in individual prevalence studies.

Data is also presented for different parts of the food chain e.g. whole animals, carcasses (some at slaughter, some at retail), portions and even comminuted products.

Data can also be presented in different ways: in some cases, a simple annual prevalence is given; on other occasions (e.g. particularly in the USA) data is in the form of compliance with a pre-established control plan.

Ideally, comparisons would be made using the same time periods and would be part of the same surveillance program with as many contributing factors as possible accounted for. The data presented below must necessarily be more pragmatic in its approach in order to compare information in a changing landscape. Countries make continual efforts to reduce pathogen levels using legislation / guidance changes and improved production practices over time, and this contributes to the need for caution when making direct comparisons.

In this summary, an attempt has been made to obtain information of as similar type as possible for all countries and to include the most recently available information from official sources, obtained for carcasses (sometimes at the slaughter establishment, sometimes at retail). *Salmonella* data will all be for presence / absence of the organism (but note that the samples may be from different sources/sites) and will generally use standard reference methods which, although different, are probably very similar in their ability to recover the organism. *Campylobacter* data will be slightly more problematic: this will have the same sampling issues as discussed with *Salmonella* testing, but testing methodology is changing with many countries reassessing a requirement to detect the organism and moving to an enumerative approach with defined enumeration criteria for acceptance or rejection. In the case of STEC, methods have also developed: older studies will only have identified *E. coli* O157 and not the presence of Shiga toxin genes in other *E. coli* serotypes.

Prevalence tables are organised by organism, meat type and then country (in alphabetical order) and are given in Tables Table 3 to

Table 6. Direct comparisons between prevalence study data are subject to the limitations described above. The references can be found in each individual country's section of the report.

Table 3: Overall summary of prevalence data – *Salmonella* (detection at 'genus' level and below)

Beef

Country	Sample type	Prevalence	Reference
Australia	Carcass after hide removal	1.33% beef, 3.75% veal (*n*=5,452)	MLA, 2017
Australia	Carcass after processing and before chill	0.34% beef, 1.4% veal (*n*=5,452)	MLA, 2017
Australia	Cuts/dice/mince	0% (*n*=54)	Anon, 2018
Botswana	Carcasses	20% (*n*=510)	DG SANCO, 2013
Botswana	Beef, comminuted, various	20% (*n*=300)	Mrema *et al.*, 2006
Botswana	Beef sausages	25% (*n*=79)	Samaxa *et al.*, 2012
Botswana	Beef products	9.9% average (*n*=354)	Gashe & Mpuchane, 2000
Brazil	Slaughter line samples	Post skin 2.2% (*n*=90) Post wash 1.1% (*n*=90) Post cool 4.4% (*n*=90)	Bier *et al.*, 2018
Brazil	Post-wash samples	1.40% (*n*=209)	Cossi *et al.*, 2014
Canada	Carcass	2.60% (*n*=666)	Lammerding *et al.*, 1988
Canada	Pre chill (after anti-microbial treatment)	0.20% (*n*=401)	Essendoubi *et al.*, 2019
Canada	Swab of carcasses in chill	0.10% (*n*=1,036)	Bohaychuk *et al.*, 2011

Country	Sample type	Prevalence	Reference
India	Beef meat samples	0.00% (*n*=50)	Kumar *et al.*, 2014
India	Beef meat samples	6.00% (*n*=50)	Kalambhe *et al.*, 2016
India	Beef carcass samples	56.00% (*n*=<266)	Bajaj *et al.*, 2003
Ireland	Carcass after hide removal	0.25% (*n*=400)	Khen *et al.*, 2014
Ireland	Ground beef	3.00% (*n*=100)	Khen *et al.*, 2014
Ireland	Beef (point in production not specified)	0.10% (*n*=27,540)	Duggan *et al.*, 2012
Ireland	Beef	0.10% (*n*=983)	FSAI, 2013
Namibia	Beef meat cuts	0.50% (*n*=3,424)	Shilangale *et al.*, 2015
Namibia	Carcass after hide removal	2.67% *(n*=1,688)	Shilangale *et al.*, 2015
Namibia	Beef products	14.00% (*n*=138)	Simasiku, 2016
UK	Beef products	1.30% (*n*=3,959)	Little *et al.*, 2008
Uruguay	Beef products	0.39% (*n*=256)	Bosilevac *et al.*, 2007
USA	Ground beef	4.20% (*n*=1,436)	Bosilevac *et al.*, 2009
USA	Ground beef	1.00% (*n*=3,904)	Zhao *et al.*, 2006; NARMS, 2005
USA	Beef retail	1.90% (*n*=210)	Zhao *et al.*, 2001
USA	Beef products	0.00% (*n*=133)	Kegode *et al.*, 2008

Lamb:

Country	Sample type	Prevalence	Reference
Australia	Meat & offal	1% (*n*=92)	Anon, 2018
Australia	Leg	2.7% (*n*=613)	Phillips *et al.*, 2013
Australia	Shoulder	0.8% (*n*=613)	Phillips *et al.*, 2013
Australia	Frozen boneless	3% (*n*=551)	Phillips *et al.*, 2013
Canada	No information		
Ireland	Lamb- further sample details not specified	0.10% (*n*=2195)	Duggan *et al.*, 2012
Netherlands	Lamb at retail	1.00% (*n*=196)	RIVM, 2018

New Zealand	Lamb at retail	1.30% (*n*=230)	Wong *et al.*, 2007a
UK	Lamb at retail	2.0% (*n*=3,959)	Little *et al.*, 2008
USA	Pre-evisceration carcass	4.40% (*n*=851)	Kalchayanand *et al.*, 2007
USA	Post intervention carcass	1.80% (*n*=851)	Kalchayanand *et al.*, 2007

Pork:

Country	Sample type	Prevalence	Reference
Canada	Swab of carcass in chill	1.60% (*n*=1,076)	Bohaychuk *et al.*, 2011
Canada	Pork at retail	0% (*n*=200)	Sanchez-Maldonado *et al.*, 2017
Chile	Pork fillets (imported into Germany)	0% (*n*=136)	Jansen *et al.*, 2018
Denmark	Carcass (serological test)	1.2% (*n*=17,905)	DTU Food, 2019
Denmark	Carcass swab	2.90% (*n*=344)	EFSA, 2008
Denmark	Pork, no details of sample type given	0.70%	Nielson *et al.*, 2001
Netherlands	Pig lymph node	8.50% (*n*=1,087)	EFSA, 2015
Netherlands	Pork, no details of sample type given	0.56% (*n*=708)	EFSA, 2015
Netherlands	Pork at retail	1.20% (*n*=313)	EFSA, 2018
UK	Carcass	5.3% (2000) (*n*=*2*,509)	Bonardi, 2017
UK	Carcass	15% (2007) (*n*=641)	EFSA 2008
UK	Pork at retail	3.9% (*n*=1,440)	Little *et al.*, 2008
UK	Carcass	15.0% (*n*=641)	EFSA, 2008
UK	Lymph node	21.0% (*n*=639)	EFSA, 2008
UK	Pork mince	1.5% (*n*=342)	Willis *et al.*, 2018
USA	Pork	16.7% (*n*=1200)	USDA Phase 1, 2015 (Scott *et al.*, 2019)
USA	Pork	13.6% (*n*=4,014) average (21.2%	USDA Phase 2, 2018 (Scott *et al.*, 2019)

		comminuted products; 8.3% intact products; 6.5% non-intact products)	
USA	Pork at retail	3.3% (*n*=209)	Zhao *et al.*, 2001

Poultry:

Country	Sample type	Prevalence	Reference
Canada	Chicken broiler lots	25.6% (*n*=4,347)	CFIA, 2016b
Canada	Retail chicken	29.0% (*n*=1,646)	CFIA, 2016b
Chile	Poultry meat	2.82 (*n*=177)	MINSAL, 2016
Chile	Carcasses at retail	1.80% (*n*=280)	Huepe *et al.*, 2010
Poland	Broiler Carcass	25.50% (*n*=419)	EFSA, 2011
Poland	Broiler Carcass	1.22% (*n*=4,331)	Witkowska *et al.*, 2018
Ukraine	Carcass, no other detail on sample type	0.43% (*n*=3,456)	DG Santé, 2018

n = total number tested

Table 4: Overall prevalence summary data – *Campylobacter* (identified to 'genus' level and below)

Beef:

Country	Sample type	Prevalence	Reference
Australia	Beef offal	14% (*n*=216)	Walker *et al.*, 2019
Australia	Whole cuts, diced & minced	2.20% (*n*=138)	Anon, 2018
Brazil	Beef at retail	0% (*n*=100)	Lopez *et al.*, 2018
Canada	Carcass	22.60% (*n*=598)	Lammerding *et al.*, 1988
Canada	Beef at retail	0% (*n*=145)	Narvaez-Brava *et al.*, 2017
Canada	Swab of carcass in chill	1.50% (*n*=1,022)	Bohaychuk *et al.*, 2011
Ireland	Beef at retail	3.20% (*n*=221)	Whyte *et al.*, 2004
Namibia		No information	

Country	Sample type	Prevalence	Reference
UK	Beef at retail	4.90% (*n*=1,563)	Little *et al.*, 2008
UK	Beef	0.13% (*n*=3,249)	ACMSF, 2019
UK	Beef trim	0.40% (*n*=250)	Bosilevac *et al.*, 2007
USA	Beef at retail	0.50% (*n*=182)	Zhao *et al.*, 2001
USA	Beef at retail	0% (*n*=133)	Kegode *et al.*, 2008

Lamb:

Country	Sample type	Prevalence	Reference
Australia	Offal	38% (*n*=208)	Walker *et al.*, 2019
Australia	Meat & offal	19.40% (*n*=180)	Anon, 2018
Australia	Shoulder	0.16% (*n*=613)	Phillips *et al.*, 2013
Canada		No information	
Ireland	Lamb at retail	11.80% (*n*=262)	Whyte *et al.*, 2004
Netherlands	Lamb at retail	2.20%	Anon, 2012
New Zealand	Lamb at retail	6.90% (*n*=1,011)	Wong *et al.*, 2007
New Zealand	Lamb trim	33% (*n*=120)	Rivas *et al.,* 2021
New Zealand	Sheep liver	66.20% (*n*=272)	Cornelius *et al.*, 2005
UK	Lamb at retail	12.60% (*n*=905)	Little *et al.*, 2008

Pork:

Country	Sample type	Prevalence	Reference
Canada	Swab of carcass in chill	8.80% (*n*=1,070)	Bohaychuk *et al.*, 2011
Chile		No information	
Denmark	Pig faecal samples	92% (*n*=1,244)	Boes *et al.*, 2005
Denmark	Pig faecal samples	96% (*n*=600)	Sorensen & Christensen, 1997
Denmark	Carcass before cooling	66% (*n*=600)	Sorensen & Christensen, 1997

Denmark	Pork at retail	3.70%	Sorensen & Christensen, 1997
Netherlands	Pork at retail	0.44% (*n*=686)	EFSA, 2015
UK	Pork at retail	6.30% (*n*=1,440)	Little *et al.*, 2008
USA	Pork at retail	1.70% (*n*=181)	Zhao *et al.*, 2001

Poultry:

Country	Sample type	Prevalence	Reference
Canada	Chicken lots	24.10% (*n*=4,253)	CFIA, 2016
Canada	Retail chicken	41.80% (*n*=1,654)	CFIA, 2016
Chile	Chicken carcass	68.70% (*n*=300)	ACHIPIA, 2017
Chile	Turkey carcass	56% (*n*=173)	ACHIPIA, 2017
Poland	Carcass	80.4 (*n*=419)	EFSA, 2010
Poland	Meat at retail	64% (*n*=181)	Szosland-Faltyn *et al.*, 2018
Poland	Carcass	60.20% (*n*=128)	Wieczorek & Osek, 2015
Poland	Meat at retail	41.60% (*n*=742)	Andrzejewska *et al.*, 2015
Poland	Carcass	60.2% (*n*=128)	Wieczorek & Osek, 2015
Poland	Carcass	53.4 (*n*= 2367)	Wieczorek *et al.,* 2020
Poland	Meat at retail	51.70% (*n*=443)	Mackiw *et al.*, 2011
UK	Meat at retail	*56% (n*=1044*)*	FSA, 2019

n = total number tested

Table 5: Overall summary of prevalence data – STEC

Beef:

Country	Sample type	Prevalence	Reference
Australia	Ground beef	16.0% (*n*=285)	Barlow *et al.*, 2006
Australia	Cattle at slaughter	4.9% adult beef (*n*=1,500) 10.5% veal (*n*=1,500) 8.4% young beef (*n*=1,500)	MLA, 2015
Brazil	Carcass swabs	27.5% (*n*=204) rainy season 17.5% (*n*=204) dry season	Castro *et al.*, 2019
Brazil	Ground beef	1.6% (*n*=250)	Castro *et al.*, 2019
Brazil	Beef at retail	2.1% (*n*=91)	Castro *et al.*, 2019
Brazil	Raw kibe	2.8% (*n*=70)	Castro *et al.*, 2019
Brazil	Meat products at retail	0.0% (*n*=552)	Castro *et al.*, 2019
Brazil	Beef jerky	0.0% (*n*=5)	Castro *et al.*, 2019
Brazil	Mato Grosso sourced beef	10.0% (*n*=980)	Castro *et al.*, 2019
Botswana	Retail beef cubes	5.2% (*n*=134)	Magwira *et al.*, 2005
Botswana	Minced beef	3.7% (*n*=133)	Magwira *et al.*, 2005
Botswana	Sausages	2.2% (*n*=133)	Magwira *et al.*, 2005
Canada	Retail beef	1.8%	Gill *et al.*, 2018
Canada	Carcass	5.2% (*n*=402) O157 3.9% (*n*=402) non-O157	Essendoubi *et al.*, 2019
Canada	Carcass pre-chill	5.5% (*n*=1,018)	Bohaychuk *et al.*, 2011
Canada	Beef	1.4% (*n*=362)	Gov of Canada, 2018
Canada	Ground beef	1.2% (*n*=589)	CFIA, 2020
India	Beef at abattoir	50% (*n*=111) (STX positives)	Khan *et al.*, 2002
India	Beef at retail	1.0% (*n*=103)	Dhanashree & Mallya, 2008
India	Minced beef	9.0% (*n*=22)	Islam *et al.*, 2008
India	Beef swabs	3.7% (*n*=27)	Islam *et al.*, 2008
Ireland	Carcass at slaughter	1.1% (*n*=450)	FSAI, 2019

Country	Sample type	Prevalence	Reference
Ireland	Carcass at slaughter	1.3% (*n*=301)	FSAI, 2019
Ireland	Beef and mince products	0.0% (*n*=172)	FSAI, 2019
Ireland	Carcass at slaughter	3.0% (*n*=132)	FSAI, 2019
Ireland	Carcass at slaughter	0.0% (*n*=250)	FSAI, 2019
Ireland	Beef mince at retail	2.8% (*n*=1,533)	FSAI, 2019
Ireland	Beef mince at retail	0.0% (*n*=800)	FSAI, 2019
Ireland	Carcass swabs	3.9% (O157) (*n*=407)	Prendergast *et al.*, 2011
Namibia	Beef trim	17.6% (*n*=771)	Molini *et al.*, 2016
UK	Beef products	0.4% (*n*=1,500)	Chapman *et al.*, 2001
Uruguay	Beef products	28% (*n*=256) (non-O157 STEC)	Bosilevac *et al.*, 2007
USA	Raw beef	0.11% (*n*=4,492) (O157), 0.58% (*n*=1,035) (non-O157)	FAS, 2020

Lamb:

Country	Sample type	Prevalence	Reference
Australia	Lamb cuts	40.0% (*n*=275)	Barlow *et al.*, 2006
Australia	Leg	0.3% (*n*=613)	MLA 2012
Australia	Shoulder	0.2% (*n*=613)	MLA 2012
Australia	Ground lamb	19.5% (*n*=194)	CFIA, 2020
Australia	Pre chill carcass swabs	0.9% (O157 only) (*n*=400)	FSAI, 2019
Ireland	Carcass swabs	2.9% (O157) (*n*=407)	Prendergast *et al.*, 2011
Ireland	Pre chill carcass	1.5% (*n*=400)	Lenahan *et al.*, 2007
Ireland	Post chill carcass	1.0% (*n*=400)	Lenahan *et al.*, 2007

Netherlands		No information	
New Zealand	Lamb at retail	14.7% (*n*=231)	Wong *et al.*, 2006
UK	Lamb (carcass and meat)	0.7% carcass, 0.8% lamb (*n*=1,500) (O157 only)	Chapman *et al.*, 2001
USA	Pre-evisceration carcass	78.6% (*n*=846) 1.6% O157 (*n*=851)	Kalchayanand *et al.*, 2007
USA	Post-intervention carcass	81.6% (*n*=846) 2.9% O157 (*n*=851)	Kalchayanand *et al.*, 2007

Pork:

Country	Sample type	Prevalence	Reference
Canada	Carcass in chill	4.80% (*n*=1,070)	Bohaychuk *et al.*, 2011
Chile	Pigs	68.30% (*n*=120)	Borie *et al.*, 1997
Denmark		No information	
Netherlands	Pork at retail	0.69% (*n*=143)	EFSA, 2018
UK	Pigs	0.30% (*n*=2,114)	Milnes *et al.*, 2008
USA	Pork	5% average (*n*=200) (5.4% comminuted; 4.9% intact products; 0% non-intact products) O157 only	USDA-FSIS Phase 1 (Scott *et al.*, 2019)
USA	Pork	0.2% (*n*=1,393) (0.44% comminuted; 0% intact products; 0% non-intact products) STEC	USDA-FSIS Phase 2 (Scott *et al.*, 2019)
USA	Pork	0% (*n*=16)	Magwedere *et al.*, 2013
USA	Pork at retail	0% (*n*=514)	Jung *et al.*, 2019

n = total number tested

Table 6: Overall summary of prevalence data – *Trichinella* (pork)

Country	Prevalence	Reference
Canada	1 premise in 2013	*Trichinella* control program
Denmark	0% (*n*=17,447,042)	DTU Food, 2018
Netherlands	0%	EFSA/ECDC, 2019
UK	0%	EFSA/ECDC, 2019
USA	0.01% (*n*=5,705)	APHIS, 2018

n = total number tested

5.8. Antimicrobial resistance (AMR)

A detailed study of the activities undertaken in the area of antimicrobial resistance in each country has not been undertaken. The individual country / meat combination chapters contain details of activity per country where found. Similarly, the overall spreadsheet summarises those countries that are actively involved in this area.

An AMR national plan was found to be in place for all countries except Namibia. Nevertheless, AMR prevalence reports and surveys of antibiotic use were not identified for all countries.

Table 7: Summary of AMR activities by country

Country	National action plan in place	Prevalence reports availability*	Survey of antibiotic use undertaken*	Evidence of efforts to reduce AMR
Australia	Yes	Yes	Yes	Yes
Botswana	Yes	Yes	Not found	Yes
Brazil	Yes	Yes	Not found	Yes
Canada	Yes	Yes	Yes	Yes
Chile	Yes	Yes	Not found	Yes
Denmark	Yes	Yes	Yes	Yes
India	Yes	Yes	Yes	Yes
Ireland	Yes	Yes	Yes	Yes
Namibia	Not found**	Yes	Not found	Yes
Netherlands	Yes	Yes	Yes	Yes
New Zealand	Yes	Yes	Yes	Yes
Poland	Yes	Yes	Yes	Yes
UK	Yes	Yes	Yes	Yes
Ukraine	Yes	Not found	Not found	Yes
Uruguay	Yes	Yes	Not found	Yes
USA	Yes	Yes	Yes	Yes

*Both official and within scientific literature
** Note “Not found” is not meant to imply that measures are not in place, simply that evidence was not found in the search sources used.

5.9. References for Chapter 5

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6. United Kingdom

6.1. Beef

6.1.1. Market overview

Cattle for the beef herd are typically bred from the dairy herd. The breeding herd was expected to contract by 1.6% during 2020 mostly due to a reduction on the breeding herd (AHDB, 2020a). There are various methods of production of beef cattle including grass-fed, feedlot and intensive farming in sheds.

The Agriculture and Horticulture Development board (AHDB) publish an annual cattle yearbook detailing animal and production figures for the UK in 2019. Details of the total number of beef holdings and average herd size are given below.

Table 8: UK – Cattle holdings and average herd size by region (June 2017)

Parameter	England	Northern Ireland	Scotland	Wales
Number of beef cow holdings*	25,759	14,724	8,989	8,238
Average beef herd size	27	18	48	N/A

Source: AHDB, 2019

*Cow holding numbers shown are based upon animals aged 2 years or over with offspring, except Wales, which are based upon all animals over 2 years as further breakdown is not available. As a result, average beef and dairy herd size figures for Wales are not available on the same basis

Latest FSA figures for approved food establishments were used to compile a list of slaughterhouses and cutting plants. As many establishments do not declare if they process beef, pork or lamb they were reported together.

Table 9: Number of registered slaughterhouses and cutting plants in the UK

Parameter	England	Northern Ireland	Scotland	Wales
Slaughterhouses – red meat	167	11	25	19
Cutting plants – red meat	52	14	2*	25*
Slaughterhouses – poultry	59	6	2	5
Cutting plants – poultry	53	15	2	5

Source: FSA, 2021

*Most entries did not specify if they were for poultry or red meat and so these figures may be inaccurate

Total beef and veal production was reported as 922,000 tonnes (AHDB, 2019). During the first quarter of 2020, the export of fresh and frozen beef increased by 8% to 33,900 tonnes while imports decreased by 11% to 61,800 tonnes. UK production of beef and veal increased by 4% to 235,900 tonnes (mostly due to increased slaughter). The largest year-on-year increases in shipments were to the Netherlands, Japan and the Philippines, which offset lower shipments to Italy, Hong Kong, France and Ireland. Imports from Ireland, the UK's largest supplier, were down 10% (AHDB, 2020a).

6.1.2. Production processes

6.1.2.1. Biosecurity

Defra provides guidance on biosecurity measures including disease control, disinfection procedures, outbreak contingency plans and more. Purchased cattle should be quarantined before introducing into the herd. As cows have long lifespan, there is a greater chance they can develop long-term diseases with extended incubation periods, particularly when considering Johne's disease or bovine tuberculosis (Defra, 2012a; AHDB, 2018a).

Retained Regulation (EU) 2016/429 on transmissible animal diseases, also known as the Animal Health Law, gives guidance on biosecurity. It contains information on disease prevention and preparation, how animals should be identified and registered, how

animals move in and out of the EU and emergency measures to be taken if an incident occurs. There are eight supplementary regulations, which are also retained.

6.1.2.2. Transport and slaughter

The UK has extensive information provided in the Meat Industry Guide, compiled by the FSA (FSA, 2018a), which ties together the retained EU legislation related to the sector and best practice. Whilst this guide is no longer being updated, it covers all aspects of the sector including rearing, slaughter, cutting and packing. More specifically around red meat, there is guidance on transporting warm carcasses before cutting, as well as cutting warm carcasses before chilling. Meat may be transported, boned and cut above 7°C provided there is appropriate Hazard Analysis and Critical Control Points (HACCP) in place, the cuts should be chilled down as soon as possible after this. Processors will likely have timelines related to quality parameters to reduce the occurrence of cold or hot shortening in the meat, these should tie up with HACCP requirements to ensure meat is still safe after cutting (FSA, 2018b).

The vast majority of beef (99%) is slaughtered using a stunning method, around 80% using captive bolt. There are some UK specific third-party assurance schemes such as Red Tractor which look to maintain animal welfare, although fewer beef slaughterhouses are part of these schemes than poultry ones (Defra, 2019).

Retained Council Regulation (EC) No 1/2005 covers the transport chain of live animals entering or leaving the EU. The regulation lays down tools for monitoring and checks to be performed by officials. For slaughter, retained Council Regulation (EC) No 1099/2009 applies for the protection of animals at the time of killing.

6.1.2.3. Ante and post-mortem inspection

The FSA's Manual for Official Controls outlines ante and post-mortem inspection. In line with retained EU legislation, in England and Wales, ante and post-mortem inspections are to be supervised by an official veterinarian (OV) or official auxiliary (OA) who is employed by the FSA. OAs are permitted to assist in ante-mortem inspection, but they must be carried out and signed off by an OV. AV may carry out post-mortem inspection but the meat they find is to be held back and further inspected by an OV. OAs are

responsible for finding visual defects, and the OVs are responsible for diagnosing disease.

6.1.2.4. Chilling and other intervention steps

Beef carcasses can either be chilled whole or cut into primals/sub-primals before chilling. This is usually using refrigerated air. Retained EU legislation specifies only a desired core temperature of 7°C and does not specify a time in which this is to be achieved (FSA, 2018c).

In line with Article 3(2) of retained Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. However, carcasses or half carcasses of cattle may also be washed with recycled hot water as per retained Commission Regulation (EU) 2015/1474. Retained Commission Regulation (EU) No 101/2013 permits the use of lactic acid on bovine carcases, half carcases, or quarters to reduce microbiological surface contamination but no other chemical can be used.

6.1.3. Microbiology

6.1.3.1. Microbiological criteria

Currently, the UK applies the requirements of retained Commission Regulation (EC) No 2073/2005 (see Annex 1). This lays down the food safety criteria for relevant foodborne bacteria and their toxins. The retained Regulation also details the sampling rules for carcasses and fresh meat; provides guidelines for sampling and sampling frequencies for carcasses, minced meat, meat preparations, mechanically separated meat and fresh meat.

6.1.3.2. Prevalence

6.1.3.2.1. *Salmonella*

In 2008, a paper (Little *et al.*, 2008) reported on the prevalence of *Salmonella* and *Campylobacter* in raw red meats. In total 3,959 raw red meats were tested between 2003-2005. It was noted that the prevalence of both organisms in beef (1.3% *Salmonella* and 4.9% *Campylobacter*) was lower than in lamb or pork.

6.1.3.2.2. *Campylobacter*

The most recent literature survey of the *Campylobacter* in UK beef was published in 2019 (ACMSF, 2019). This noted that available data was dated, but that a survey done in 2006-2007 (FSA, 2010) in which 3,249 beef samples were tested indicated 4 were positive, a prevalence of 0.13% (ACMSF, 2010).

Table 10: UK, Beef – Prevalence of *Salmonella* and *Campylobacter*

Microorganism	% prevalence	Reference
Salmonella	1.3%	Little *et al.*, 2008
Campylobacter	4.9%	Little *et al.*, 2008
Campylobacter	0.13%	ACMSF, 2019

6.1.3.2.3. STEC

Data on the prevalence of STEC in UK beef is limited and made more difficult by the challenges of test method. Until very recently, the limited testing done in the UK only looked for *E. coli* O157 and not all STEC organisms. This could potentially quite drastically underestimate the prevalence of STEC in beef in the UK. One of the few papers that gives any information on UK prevalence was produced in 2001 (Chapman *et al.*, 2001), it only considered *E. coli* O157. In this study meat samples were obtained from 1500 beef and 1,500 lamb carcasses. All samples were examined for *E. coli* O157. *E. coli* O157 was isolated from 22 (0.44%) of 4,983 raw meat products. *E. coli* O157 was isolated more frequently from lamb products (0.8%) than from beef products (0.4%). RASFF alerts show 9 incidences of contamination with Shiga toxin-producing strains between 2000 and 2021 where the UK was the country of origin. Whereas the level of contamination of post-slaughter samples has not been extensively studied for UK produced meat, prevalence in cattle has been examined in more depth.

One study (Gunn *et al.*, 2007) showed that 7.9% of Scottish beef finishing cattle were positive for toxin producing *E. coli*, and that in positive groups 25% of the animals shed the organism. This level of prevalence is similar for the recent BECS survey of UK prevalence of *E. coli* O157, which reported rates of 10.6% and 6.9% positive faecal samples for Scottish and English & Welsh samples respectively (FSS, 2018).

Food Standards Scotland is funding a study which will consider the prevalence of STEC in minced beef on sale in Scotland. The results of this study are due to be published in early 2021.

6.2. Lamb

6.2.1. Market overview

A survey of abattoirs indicated that nearly all UK cattle, pigs and poultry are sourced directly from farms, whereas around 50% of sheep are acquired from markets (Defra, 2019). The number of red meat slaughterhouses and cutting plants can be found in section 6.1.1.

The forecast provided by AHDB (2020b) indicates that the size of the breeding stock was expected to remain steady at 13.8 million head, whilst the lamb crop (16.8 million head), lamb slaughter (12.6 million head), and ewe slaughter (1.5 million head) were all expected to decrease throughout 2020.

A 7% reduction in lamb production was expected in 2020. Imports have also reduced this year due to less availability from the UK's main imports of Australia and New Zealand where the drought has shrunk flock size. Whilst import from New Zealand and Ireland were down, imports from Australia were up slightly (AHDB, 2020b).

6.2.2. Production processes

6.2.2.1. Biosecurity

Defra provides guidance on biosecurity measures including disease control, disinfection procedures, outbreak contingency plans and more. Purchased sheep should be quarantined before introducing into the herd. Diseased animals are to be reported to the Animal Health Veterinary Laboratories Agency (AHVLA) (Defra, 2012a; Defra, 2012b).

Information on retained EU regulation on biosecurity can be found in section 6.1.2.1.

6.2.2.2. Transport and slaughter

Whilst the vast majority of UK beef and pork are irreversibly stunned before slaughter, 70% of lamb is reversibly or non-stunned for Halal (Defra, 2019).

More information on UK guidance and retained EU regulation of transport and slaughter can be found in section 6.1.2.2.

6.2.2.3. Ante and post-mortem inspection

The requirements for beef, lamb and pork are the same in the UK, more information can be found in section 6.1.2.3.

6.2.2.4. Chilling and other intervention steps

Lamb carcasses can either be chilled whole or cut into primals/sub-primals before chilling. This is usually using refrigerated air. EU legislation specifies only a desired core temperature of 7°C and does not specify a time in which this is to be achieved (FSA, 2018).

In line with Article 3(2) of retained Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. However, carcasses or half carcasses of sheep may also be washed with recycled hot water as per retained Commission Regulation (EU) 2015/1474. Additional chemicals may not be used.

6.2.3. Microbiology

6.2.3.1. Microbiological criteria

Currently, the UK applies the requirements of retained Commission Regulation (EC) No 2073/2005 (see Annex 1).

6.2.3.2. Prevalence

6.2.3.2.1. *Salmonella*

The most recent large-scale survey of *Salmonella* in lamb was published in 2008, from data collected between 2003 and 2005 (Little *et al.*, 2008). This survey tested 3,959 raw red meats. Lamb was noted with a *Salmonella* prevalence of 2%. *Salmonella* does not cause a high proportion of illnesses associated with lamb (Tam *et al.*, 2012), and this is reflected in the focus of published literature on risks associated with it.

6.2.3.2.2. *Campylobacter*

The report of Little *et al.* (2008) also considered the prevalence of *Campylobacter* in lamb. Lamb was noted to have a *Campylobacter* prevalence of 12.6%. *Campylobacter* poisoning is not noted to be caused by contaminated lamb (Tam *et al.*, 2012)

6.2.3.2.3. STEC

A survey done in Yorkshire and reported in 2001 (Chapman *et al.*, 2001) reported on the prevalence of *E. coli* O157 in sheep carcasses and meat. It should be noted that at this time the serogroup O157 was the only STEC acknowledged to be widely pathogenic to humans and there were no methods available to test for the much wider STEC group.

Results indicated that of 1,500 lamb carcasses examined, 10 (0.7%) were positive for *E. coli* O157. From raw meat products, *E. coli* O157 was isolated at a prevalence of 0.8%.

6.3. Pork

6.3.1. Market overview

Imported pork (874,000 tonnes carcass weight equivalent in 2020) is sourced wholly from the EU whilst the UK exports approximately 54% of pork to the EU and the remainder to the rest of the world (AHDB, 2020c). The number of red meat slaughterhouses and cutting plants can be found in section 6.1.1.

6.3.2. Production processes

Pig farming is split into three stages before slaughter. First female pigs (sows) become pregnant and are kept in group housing or outdoor systems until they are ready to give birth. Giving birth (farrowing) is performed in individual shelters known as arcs where the piglets are kept inside for around 28 days. Once the pigs reach maturity, mostly reared outdoors, they are moved inside for finishing. Only a small percentage of pigs are finished in outdoor systems (RSPCA, 2019).

6.3.2.1. Biosecurity

AHDB have a set of standard operating procedures for biosecurity on pig farms including the handling of live animals, people, vehicles and transporting livestock (AHDB, 2020d).

Information on retained EU regulation on biosecurity can be found in section 6.1.2.1.

6.3.2.2. Transport and slaughter

More information on UK guidance and retained EU regulation of transport and slaughter can be found in section 6.1.2.2.

6.3.2.3. Ante and post-mortem inspection

The requirements for beef, lamb and pork are the same in the UK, more information can be found in section 6.1.2.3.

6.3.2.4. Chilling and other intervention steps

In line with Article 3(2) of retained Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. However, carcasses or half carcasses of pigs may also be washed with recycled hot water as per retained Commission Regulation (EU) 2015/1474. Additional chemicals may not be used.

6.3.3. Microbiology

6.3.3.1. Microbiological criteria

Currently, the UK applies the requirements of retained Commission Regulation (EC) No 2073/2005 (see Annex 1).

6.3.3.2. Prevalence

6.3.3.2.1. *Salmonella*

Bonardi (2017) reviewed that area of *Salmonella* carriage in pigs. That review contains data on UK levels in carcasses giving prevalence levels of 5.3% in 1999-2000 and 15% in 2006-2007.

A paper by Little *et al.* (2008) looked at prevalence of *Salmonella* and *Campylobacter* in raw red meats between 2003 and 2005. Of all red meats types, pork had the highest contamination with *Salmonella* noted as being 3.9%.

Also, in 2008, EFSA released their baseline survey report on *Salmonella* in pork. In this, the UK was noted as having a prevalence of 15.1% (97 from 641 positive) on carcass swabs, and 21% (139 out of 639 positive) in lymph nodes.

A report to the UK FSA by Willis *et al.* (2018) with more recent data noted that *Salmonella* was detected in 5 out of 342 (1.5%) pork mince samples (25 g) and none of the isolates displayed resistance to any of the highest-priority critically important antibiotics for human medicine. Four were identified as *Salmonella enterica* serovar Typhimurium and one as *Salmonella enterica* serovar Derby.

6.3.3.2.2. *Campylobacter*

A paper by Little *et al.* (2008) looked at prevalence of *Salmonella* and *Campylobacter* in raw red meats between 2003 and 2005. Pork had the second lowest prevalence of *Campylobacter* (beef was the lowest) at a level of 6.3%.

Willis *et al.* (2018) surveyed chicken and pork for pathogens, however, pork did not appear to have been tested for *Campylobacter* due to a lack of retail minced pork.

6.3.3.2.3. STEC

Data on STEC prevalence is pork appears limited. One paper reported on intestinal contamination of pigs with STEC O157 at slaughter (Milnes *et al.*, 2008), which gave a prevalence value of 0.3% (compared to 0.7% in sheep and 4.7% in cattle). It should be noted that the tests done only allow reporting on *E. coli* O157 and no other serogroups were tested.

6.3.3.2.4. *Trichinella*

Sampling and testing for *Trichinella* falls under retained Commission Implementing Regulation (EU) 2015/1375. Testing is done on every carcass. If *Trichinella* is not found, the carcass is released.

The EU One Health Report indicates that the UK had no *Trichinella* positives in pigs or boar in 2018 (EFSA and ECDC, 2019).

6.4. Poultry

6.4.1. Market overview

Britain's poultry meat market is valued at £7.2 billion and produces half the meat eaten in the country (BPC). The number of poultry slaughterhouses and cutting plants can be found in section 6.1.1.

In 2020, the UK produced 1.091 billion head of poultry meat (Defra, 2021). 344,850 tons of poultry meat is exported whilst 456,122 tonnes are imported (total UK imports) (AHDB, 2018b).

6.4.2. Production processes

The poultry industry is based upon a typical breeding pyramid whereby a comparatively small number of elite breeding stock birds (grandparents and parents) are used to produce many broilers, e.g. one elite female could be the origin of up to 280,000 broilers (EFSA, 2019a). Such breeding flocks are reported to be normally kept under conditions of extremely high biosecurity and in the case of chickens, normally in regions where there is a low prevalence of *Salmonella* and a low risk of other avian diseases (EFSA, 2016). Primary breeding of chickens is managed by a small number of companies globally and regulations are in place to control the associated trade and movement of animals (EFSA, 2019a; Houses of Parliament, 2011).

In the UK, the total poultry population is over 180 million of which in the order of 53 million are breeding and laying fowl and 118 million are broilers (AHDB, 2018b). On average 20 million birds are slaughtered each week (Defra, 2020). In 2011, there were four breeding companies for broilers, and these operated internationally (Houses of Parliament, 2011).

Most poultry meat is produced on large (intensive) farms (i.e. have the capacity to house approximately 40,000 birds). There are a variety of models, however, the main processors either operate or partner with independent poultry rearing farms across the UK. The independent farms themselves may be owned, rented or leased.

6.4.2.1. Biosecurity

At the initial production stage, the basic requirements include the provision of an ideal physical environment, minimizing exposure to diseases, meeting the birds' behavioural and social needs, and providing them with clean water and good-quality feed that satisfies their nutrient requirements (FAO). These issues are encompassed by animal welfare considerations and do not necessarily impact on food safety.

Defra's code of practice for chicken welfare advises that keeping poultry house litter dry and minimising water spillages can reduce chances of spreading disease. Both *Campylobacter* and *Salmonella* can be carried on a bird's beak from pecking the litter or feathers, and *Salmonella* can also be transmitted through the feed (Defra, 2018).

In 2019, the UK Advisory Committee on the Microbiological Safety of Food (ACMSF) issued their third report on *Campylobacter*. They noted an EFSA review that categorised intervention strategies to minimise *Campylobacter* throughout chicken production (EFSA, 2011).

Information on retained EU regulation on biosecurity can be found in section 6.1.2.1.

6.4.2.2. Transport and slaughter

To transport poultry within Great Britain a certificate of vehicle approval from the Animal and Plant Health Agency (APHA) is required. The type of certificate changes depending on if the journey will be less than or greater than 8 hours. These certificates are not required if the journey is less than 65 km. An animal transport certificate issued by the APHA is required for any type of journey involving live poultry; this captures the origin and ownership of the animals, place of departure and destination, starting time and date as well as when the journey is expected to finish. When transporting poultry, the journey should be kept as short as possible, the animals must be checked during the journey for water, feed and rest. The vehicle must be suitable for transport in that the poultry are given enough floor space and height (APHA, 2021).

Stunning poultry before slaughter is mandatory in the UK aside from cases involving religious slaughter such as Halal and Kosher. Stunning methods permitted are electrical, gas or water bath. Equipment used to stun must do so rapidly and effectively, and

slaughter lines must be monitored to ensure this is being performed correctly. Birds must be in contact with electrical current for at least 4 seconds and the voltage applied must be strong enough. Minimum voltage and current settings for electrical water baths are supplied by Defra and these must be monitored routinely by the slaughterhouse. For gas stunning, carbon dioxide in high concentration (>40%), inert gases, a mixture of inert and carbon dioxide gases, or two stages of carbon dioxide are permitted. Small bird such as broilers must be bled for at least 90 seconds, larger birds for 2 minutes (Defra, 2019).

Information on retained EU regulation of transport and slaughter can be found in section 6.1.2.2.

6.4.2.3. Ante and post-mortem inspection

Results of the ante-mortem inspection are input into the “trigger system” created with Defra to identify possible welfare problems on the farm. The triggers are two tier and if a trigger report is created it is sent to the farm so they can make improvements. It is also used by the Animal and Plant Health Agency (APHA) to target inspections for farms with poor welfare conditions. Farms above a stocking density of 33 kg/m^2 must provide the cumulative daily mortality rate (CDMR) of each house and the breed on its food chain information report (FCI). The CDMR and total mortality should be similar but if flock thinning is taking place (where a proportion of birds are removed for slaughter before the rest) or there is a high mortality then the figures could be further apart.

FSA provides ante-mortem inspection guidance in the Manual for Official Controls Amendment 84 Chapter 2.2. Inspections must be performed by an official veterinarian (OV). Specific requirements are provided in Section II of Annex III to retained Regulation (EC) No 853/2004.

At post-mortem inspection, the viscera and carcass are inspected by an OV or trained staff for signs of disease. These conditions are marked and monitored routinely as part of QA checks by the OV. The viscera are then separated into human grade and non-human grade parts on a separate line. OVs are employed by the FSA to conduct inspection.

6.4.2.4. Chilling and other intervention steps

Carcasses travel through two chillers: one to bring the carcass down to 20°C; the second with high air flow to reach below 3°C before being further processed into separate cuts or trussed as whole birds. This cannot be done too quickly or quality issues due to rigor mortis can be present (e.g. cold shortening). Birds are automatically sorted into containers by a machine whilst still shackled, this is by weight (no human contact).

Chilling time can vary depending on carcass size but may define microbiological status of meat. Legislation does not define a chilling time, just that the final meat temperature must be below 4°C before transport or cutting. In the EU, poultry is mostly air chilled. The EU recommends a maximum of 4.5% moisture absorbed by the carcass during water immersion chilling and 2% for air chilling.

In line with Article 3(2) of retained Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. Additional chemicals may not be used.

6.4.3. Microbiology

6.4.3.1. Microbiological criteria

Currently, the UK applies retained EU legislation relating to microbiological criteria (see Annex 1). Retained Commission Regulation (EC) No 2073/2005 applies to a range of food types, but within it there are a number of criteria relating to poultry carcasses and meat. All criteria relate to *Salmonella* and *Campylobacter*. In the safety criteria for poultry meat and products there is a requirement for tests to show that *Salmonella* is not detected, in fresh poultry meat. The criteria are specific for two serotypes – *Salmonella* Typhimurium and *Salmonella* Enteritidis. There are no *Campylobacter* food safety criteria.

In carcasses the process hygiene criteria cover *Salmonella* and *Campylobacter*. *Salmonella* require serotyping (to establish if isolates are *Salmonella* Typhimurium or *Salmonella* Enteritidis*)*. *Campylobacter* criteria are set at enumeration and the gradually reducing acceptable numbers over time is aimed at reducing the numbers of highly contaminated carcasses.

Over recent years in the UK, the FSA/FSS have been working closely with major food retailers to attempt to reduce the numbers of poultry contaminated with *Campylobacter* at the highest level (i.e. >1000 cfu/g), as various models have indicated that this could reduce numbers of human illness caused by the organism. The objective was to reduce the percentage of carcasses contaminated at >1000 cfu/g from 27% in 2008 to below 10% post chill in the slaughterhouse and <7% at retail.

This initiative appeared to be successful with percentages at retail containing >1000 cfu/g having fallen from 18.4% in 2014 to 7% in 2017 (Jorgensen *et al.*, 2019).

6.4.3.2. Prevalence

6.4.3.2.1. *Salmonella* and *Campylobacter*

In the UK, a survey of *Campylobacter* contamination of chicken skin at retail has been undertaken since 2014. This is measured in terms of the number of colony forming units per gram of skin (cfu/g). The primary focus of attention is on high levels of *Campylobacter* – namely, those over 1,000 cfu/g. The top nine retailers have conducted their own tests (according to FSA protocols) since 2017 and publish their own results on their websites. The results indicated that the percentage of chicken skin samples with >1000 cfu/g *Campylobacter* levels reduced by 0.7% during 2018 (from 3.8% to 3.1%), remaining steady in whole, chilled, UK-produced chickens sold by major retailers, according to their own figures. The average overall contamination rates were reported to be approx. 60% < 10 cfu/g; 24% 10-99 cfu/g; 13% 100-1,000 cfu/g; 3% > 1,000 (FSA, 2019).

The UK has also introduced a *Campylobacter* proficiency testing scheme for those laboratories undertaking detection and enumeration testing for retailers.

According to an EU-wide baseline survey that was carried out at slaughterhouse level in 2008, the prevalence of *Campylobacter*-colonised broiler batches was 71.2% and that of *Campylobacter*-contaminated broiler carcasses was 75.8% (EC, 2017).

Salmonella contamination was a major problem in UK produced poultry and poultry products for many years. The introduction of vaccination of poultry flocks against the major serotypes, reduced poultry contamination considerably and gave a reduction in cases of food poisoning caused by the main poultry derived serotype (*Salmonella*

Enteritidis). Many poultry producing countries have had similar successes with reducing contaminations levels in poultry flocks and generally *Salmonella* prevalence in poultry flocks is currently considerably lower than that of *Campylobacter* (O'Brien, 2013).

A major survey of levels of *Salmonella* and *Campylobacter* in fresh and frozen chicken on retail sale in the UK was completed in 2001 (FSA, 2003). Note that in this work *Campylobacter* reporting was done using presence or absence, not enumeration. The results are summarised below as an illustration of the difference in contamination rates found in directly comparable samples.

Table 11: UK, Poultry – Produced chicken (% positives) – *Salmonella* and *Campylobacter* (2001 survey)

Microorganism	Fresh chicken	Frozen chicken
Salmonella	3.9	8.3
Campylobacter (whole chicken)	61	54

6.4.3.2.2. *Salmonella*

The latest results from EFSA (2019) show that from a sample number of 163 broiler flocks tested by competent authorities, 0.61% were positive for the target serovars. Of the 57,011 flocks tested and reported by the FBO, 0.04% tested positive. Of the 2,604 fattening turkey flocks sampled by FBOs, 0.31% tested positive for the target serovars.

6.4.3.2.3. *Campylobacter*

The UK Food Standards Agency (FSA) agreed with industry to reduce *Campylobacter* contamination in raw chicken. The target was to reduce the percentage of chickens produced in UK poultry slaughterhouses that are contaminated with >1,000 cfu/g, to 7% or less at retail level (FSA, 2019).

Consequently, the FSA commissioned a number of microbiological surveys of *Campylobacter* contamination in fresh whole UK produced chilled chicken at retail sale which has undertaken by Public Health England. The first survey covered the period 2014-2015 whilst the latest covered 2017-2018 (FSA, 2019).

This report gives the overall level of *Campylobacter* contamination (2017 to July 2018) from major retailers as being 56% with 7% of samples having a level of over 1,000 cfu/g. The previous results show that in October-December 2015, 10.7% of chickens (skin samples) had high levels of *Campylobacter* (over 1,000 cfu/g), a statistically significant reduction from 18.9% over the same period the previous year (October-December 2014). This therefore indicates a reduction in the levels of *Campylobacter* contamination on poultry carcasses at retail.

However, part of the most recent survey did look at minor retailers. Results from this group appeared different with a higher level of contamination. *Campylobacter* were detected in 75% of these samples with 15% having levels above 1,000 cfu/g.

The information from the UK in the EFSA zoonoses monitoring results, submitted to the European Commission in accordance with Article 9 of Directive 2003/99/EC, for *Campylobacter* in 2017 and 2018 gives the following information:

Table 12: UK, Poultry – *Campylobacter* monitoring results (2017-2018)

Organism	Number tested 2017	Number tested 2018	Number positive 2017	Number positive 2018	2017 (%)	2018 (%)
Campylobacter	4,069	1,460	2,015	873	49.5	59.0

6.5. Antimicrobial resistance

Although no longer a member of the EU, the United Kingdom inherited EU policies on monitoring and restricting use of antibiotics in animals (EC, 2017). The UK's 20-year vision (DHSC, 2019a) and 5-year national action plan (DHSC, 2019b) outlines the UK's contribution to containing and controlling antimicrobial resistance in health, animals, the environment and the food chain. This was co-developed across government, its agencies, the health family and administrations in Scotland, Wales and Northern Ireland with support from a range of stakeholders. A number of organisations have also produced guidance and guidelines on the responsible use of antibiotics. For instance, new targets were recently set by Responsible Use of Medicines in Agriculture Alliance (RUMA, 2020).

In 2022, new legislation, Regulation (EU) 2019/4 and Regulation (EU) 2019/6, prohibiting all forms of routine antibiotic use for prophylaxis and growth promotion in farming within the EU will come into force. It will be applicable in the UK as a retained EU legislation.

Data from the European Medicines Agency (EMA, 2020) suggests that, for the 25 countries which provided sales data for all years between 2011 and 2018, an overall decline in sales of antibiotics for use in animals (in mg/PCU) of 34.6% was observed in Europe. For the UK, the EMA report indicated an even more significant drop in annual sales of veterinary antimicrobial agents for food producing species – from 67.9 mg/PCU in 2010 to 29.5 mg/PCU in 2018 (fifth-lowest among 31 countries covered). The latest figure is lower than that in Denmark (by 29%), Ireland (by 56%), the Netherlands (by 95%), and Poland (by 467%).

O'Neill (2015) ranked the United Kingdom as the fifteenth-lowest for antibiotic use in agriculture among the 29 countries examined at the time of the review.

Annually within the EU, the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control (ECDC) collect, analyse and publish data on antimicrobial resistance in EU member states (EFSA and ECDC, 2020). The report summary in 2020 stated that in food-producing animals, the summary indicator of susceptibility to all antimicrobials has increased in *E. coli* in just under 25% of Member States over the period 2014-2018. This is a positive development as it means that in

these countries, in case of need, treatments with antimicrobials would have a higher chance to be successful. For the United Kingdom, the report revealed that only 4 isolates of *Salmonella* spp. from fattening pig carcasses were tested in 2017 and resistances to ampicillin, sulfamethoxazole, and tetracycline were detected. Significant levels of resistance were found in indicator *E. coli* from fattening pigs for chloramphenicol (20.4%), ampicillin (30.6%), sulfamethoxazole (47.3%), trimethoprim (36.6%), and tetracycline 59.1%) in 2017 (*n* = 186).

For poultry, the report did not indicate any significant levels of resistance in *Salmonella* spp. from carcasses of broilers in 2018 (*n* = 100). The occurrence of resistance in *Salmonella* spp. from broiler flocks was found to be below 7% for all selected antimicrobials in 2018 (*n* = 171). Significant levels of resistance in indicator *C. jejuni* from broilers were reported for nalidixic acid (48.8%), ciprofloxacin (48.3%), and tetracycline (65.1%) in 2018 (*n* = 172). Also, significant levels of resistance were found in indicator *E. coli* from broilers for gentamicin (10.4%), ampicillin (46.4%), nalidixic acid (14.8%), ciprofloxacin (15.8%), sulfamethoxazole (40.4%), trimethoprim (27.3%), and tetracycline (26.8%) in 2018 (*n* = 183).

The EFSA and ECDC report did not provide any data on the prevalence of antimicrobial resistance related to beef or lamb other than that the prevalence of presumptive ESBL- and/or AmpC-producing *E. coli* isolates from retail bovine meat collected in 2017 was found to be 0.6% (*n* = 314). The same from broiler meat collected in 2018 and from retail pig meat collected in 2017 was found to be 13.6% (*n* = 309) and 0.3% (*n* = 310), respectively.

Mateus *et al.* (2016) concluded that antimicrobial resistance data from British & imported pork meat in the UK were lacking and dated and that further research and surveillance was needed. Pork as well as beef in retail were then tested in 2015, 2017, and 2019 as part of the EU Harmonised Survey of Antimicrobial Resistance on retail meats (FSA, 2020). The results for 2019 show that less than 1% of tested retail beef and pork samples in the UK were positive for AmpC or ESBL-producing *E. coli*, and these results were in line with the results for 2015 and 2017. In 2019, none of the beef and pork samples were positive for *E.coli* with resistance to last resort carbapenem or colistin antibiotics. FSA considered that the UK results compared favourably with those from the rest of Europe.

Willis *et al.* (2018) reported that *Salmonella* was detected in 5 out of 342 (1.5%) pork mince samples and none of the isolates displayed resistance to any of the highest-priority critically important antibiotics for human medicine. Four were identified as *Salmonella enterica* serovar Typhimurium and one as *Salmonella enterica* serovar Derby. All four *Salmonella* Typhimurium isolates were resistant to ampicillin and tetracycline (as well as having reduced susceptibility to sulfamethoxazole), with one also showing resistance to chloramphenicol, whilst the *Salmonella* Derby isolate was susceptible to all antimicrobials except sulfamethoxazole. None of the *Salmonella* had phenotypes consistent with the production of ESBL or AmpC enzymes. This study also considered *Campylobacter,* which were detected in 25% (*n*=339) of all chicken samples (fresh and frozen), it was noted that the overall prevalence was adversely affected by the negative effects of freezing on *Campylobacter*. Of the isolates of *C. coli* examined 46.7% were resistant to ciprofloxacin, 6.7% to erythromycin and 60% to tetracycline. For the *C. jejuni* isolates 38.9% were resistant to ciprofloxacin, 7.6% to erythromycin and 61.8% to tetracycline. All isolates were sensitive to gentamycin and a single *C. coli* was resistant to streptomycin. Multidrug resistance was found in 8.9% *C.coli* and 0.6% of *C.jejuni.* Willis *et al.* also commented on E.coli that were isolated more frequently in chicken samples (49% of samples) than pork mince (10% of samples). A higher percentage of the chicken isolates had resistance to ciprofloxacin, nalidixic acid and gentamycin (26%; 25% and 7%), compared to those from pork (13%; 3% and 0%). However, resistance to chloramphenicol and tetracycline occurred more often in pork isolates (72% and 23%) than from chicken (37% and 7%). ESBL *E.coli* were detected in 6.5% of meat samples tested (4.7% of pork samples and 8.3% of chicken samples). It was reported that the results from retail chicken showed a decrease in the proportion of ESBL *E.coli* positive samples compared to earlier surveys (65.4% in 2013/4 and 29.7% in 2016).

A study by Davies *et al.* (2017) considered antibiotic usage in British sheep flocks. They noted mean and median usage was 11.38 and 5.95 (mg/PCU) respectively. The authors noted that this was considered low in comparison with the suggested target (an average across all the UK livestock sectors) of 50 mg/PCU at the time (RUMA, 2017).

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7. Denmark

7.1. Pork

7.1.1. Market overview

Some Danish pig herds are very large, with around 15% of farms at greater than 8,000 pigs, these farms house around 50% of the pigs in the country. There is a band of smaller farms with between 1,000-3,000 pigs (25% of farms), 30% are spread between 3,000-8,000 pigs per farm, around 10% of farms have less than 50 pigs. 75% of the pig population is reared in the Jutland regions, the rest is spread between Eastern Denmark and Funen.

The number of pigs slaughtered has fallen in recent years and the herd size has remained fairly stable, there has been an increase in export of weaners. Around 50% of exports are pigmeat, the other 50% is live animals. The total pigmeat production for 2019 was 1.5 million tonnes which accounts for around 6.5% of EU production.

Most live pigs and sows are sent to Germany and Poland, whereas UK is the main destination for bacon. Cuts are mainly sent to Germany, Poland, UK and Italy. China have recently ceased most of the import of Danish pork by-products, which is now traded to other non-EU countries, but their import of sausages has increased (DAFC, 2020).

7.1.2. Production processes

7.1.2.1. Biosecurity

Denmark has built a fence on the border to Germany to ensure wild boar do not cross the border, this is a control measure against African swine fever which has been a problem in some neighbouring countries in recent years. There are some concerns that this is not entirely effective as many boars are able to cross between the countries by water on the east coast (ter Beek, 2020).

Denmark authorities have declared the east region of Germany bordering with Poland a high-risk area, most of Eastern Europe and Belgium. Hauliers travelling from high risk zones are required to travel directly to a Danish approved vehicle cleaning centre when

crossing the border and are only allowed to head to Danish approved collection centres within the following seven days. More detailed information on transporting pigs is available in the Danish Transport Standard (SEGES, 2020a).

Information on EU regulation on biosecurity can be found in section 6.1.2.1.

7.1.2.2. Transport and slaughter

There is a Danish Product Standard which is a quality assurance scheme for pig producers. This gives guidance on industry standards for animal traceability, feed, herd health, use of medicine and welfare/biosecurity standards for transport of livestock (SEGES, 2020b). Guidelines appear to be in-line with those required for EU production.

Information on EU regulation of transport and slaughter can be found in section 6.1.2.2.

7.1.2.3. Ante and post-mortem inspection

Meat inspection is overseen by the Meat Inspection Department, this includes before and after slaughter, inspecting carcass and viscera and deboning procedures. They are permitted to use contract veterinarians or auxiliaries to carry out meat inspection at slaughterhouses (DVFA, 2017).

7.1.2.4. Chilling and other intervention steps

Denmark follows Regulation (EC) No 853/2004 which sets criteria on washing and chilling. Meat must be chilled down to 7°C as soon as possible (3°C for offal) and air temperature must be below 12°C during deboning and cutting procedures.

In line with Article 3(2) of Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. However, carcasses or half carcasses of pigs may also be washed with recycled hot water as per Commission Regulation (EU) 2015/1474. Additional chemicals may not be used.

7.1.3. Microbiology

7.1.3.1. Microbiological criteria

As a member of the European Union, Denmark is governed by EU law i.e. Commission Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs (Annex 1).

7.1.3.2. Prevalence

7.1.3.2.1. *Salmonella*

Denmark operates a *Salmonella* surveillance programme which involves regular monitoring and assessment. One of the most recent monitoring reports (DTU Food, 2019) noted (source Table A11) a maximum prevalence of 1.2% (*n* = 17,905) in slaughterhouses killing >30,000 pigs / year. In slaughterhouses killing lower numbers, a prevalence of 0% appears to be noted although the sample size was only 151. This compares with the previous report (DTU Food, 2018) where the reported figures noted (source Table A12) a prevalence of 0.7% and 14.9% (based on serological tests) respectively.

In 2008, EFSA (source Table V1.9) published a report on *Salmonella* in pigs in the EU. This did report prevalence data for Danish carcass swabs with 10 out of 344 carcasses positive and a prevalence of 2.9% (the same report noted a seroprevalence in meat juice of 7%, and a prevalence in lymph nodes of 8%).

A report in 2001 (Nielson *et al.*, 2001) noted that *Salmonella* prevalence in Danish pork had declined from 3.5% in 1993 to 0.7% in 2000.

It should be noted that the seroprevalence is based on detecting antibodies to *Salmonella* in meat juice, this may not mean that the sample contains *Salmonella* at that point, but that the animal had been infected at some point in the past.

In FSIS country reports on Denmark in 2018 and 2020 the national prevalence of *Salmonella* in swine carcasses is estimated to be 8.7% (FSIS, 2018; 2020). However, in the newer report it would appear that the 8.7% figure may be a maximum allowable level and not an actual prevalence.

7.1.3.2.2. *Campylobacter*

A paper by Boes *et al.* (2005) reported that over 92% of pigs tested (faecal samples) were *Campylobacter* positive.

An early study was conducted in 1997 (Sorensen & Christensen) on the incidence of *Campylobacter* spp. in pig (swine) faeces and pig carcasses in 3 slaughterhouses in Denmark. Tests on faeces samples from 600 pigs showed that 578 (96%) contained *Campylobacter* species. *Campylobacter* species. were detected on 397 (66%) carcasses before cooling; Studies on samples of fresh pork showed low incidence of *Campylobacter* spp. (up to 3.7%).

More recent data on *Campylobacter* levels in pork meat were not identified.

7.1.3.2.3. STEC

No data could be found on prevalence of STEC in Danish pork.

7.1.3.2.4. *Trichinella*

As Denmark is a Member State of the EU, sampling and testing for *Trichinella* falls under Commission Implementing Regulation (EU) 2015/1375.

This states that:

“Carcasses of domestic swine shall be sampled in slaughterhouses as part of the post-mortem examination as follows:

a) all carcasses of breeding sows and boars or at least 10 % of carcasses of animals sent in for slaughter each year from each holding that is officially recognised as applying controlled housing conditions, shall be examined for *Trichinella*;

b) all carcasses from holdings that are not officially recognised as applying controlled housing conditions shall be systematically examined for *Trichinella*.

A sample shall be collected from each carcass and the sample shall be examined for Trichinella, in a laboratory designated by the competent authority.

Cutting of the carcass into no more than 6 parts can be done before results of the test are available (as long as full traceability is assured). A positive result would mean that carcass and all parts are unfit for human consumption."

It is noted that 16,858,136 pork samples were examined in 2017, and zero were positive (DTU Food, 2018). Similarly, the next annual report indicates that 17,447,042 samples were tested for *Trichinella* species and none were positive (DTU Food, 2019).

In the above studies samples collected from slaughter pigs at slaughter were examined using the method described in Commission Implementing Regulation (EU) 2015/1375. In 2014, an amendment to Commission Regulation (EC) No 2075/2005 came into force stating that slaughter pigs, sows and boars kept under "controlled housing conditions" in Denmark are exempted testing for *Trichinella*. Free-range pigs must be tested for *Trichinella*.

7.2. Antimicrobial resistance

EU policies on monitoring and restricting use of antibiotics in animals are followed by Denmark. As a member of the EU, Denmark will implement the EU One Health Action Plan against Antimicrobial Resistance (AMR) (EC, 2017; MFVM, 2019).

In 2022, new legislation, Regulation (EU) 2019/4 and Regulation (EU) 2019/6, prohibiting all forms of routine antibiotic use for prophylaxis and growth promotion in farming within the EU will come into force. It will be applicable in the UK as a retained EU legislation.

Data from the European Medicines Agency (EMA, 2020) on the sales of veterinary antimicrobials in Europe suggests that, for the 25 countries which provided sales data for all years between 2011 and 2018, an overall decline in sales of antibiotics for use in animals (in mg/PCU) of 34.6% was observed. For Denmark, the EMA report indicated a somewhat modest decrease in annual sales of veterinary antimicrobial agents for food producing species – from 47.5 mg/PCU in 2010 to 38.2 mg/PCU in 2018 (fifth-lowest among 31 countries covered). The latest figure is greater than that in the UK (by 29%), but lower than in Ireland (by 21%), the Netherlands (by 50%), and Poland (by 338%).

O'Neill (2015) ranked Denmark as the tenth-lowest for antibiotic use in agriculture among the 29 countries examined at the time of the review.

As noted in section 6.5, annually within the EU, the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control (ECDC) collect, analyse and publish data on antimicrobial resistance in EU member states (EFSA and ECDC, 2020). For Denmark, significant levels of resistance in *Salmonella* spp. from fattening pig carcasses to gentamicin (7.2%), chloramphenicol (14.5%), ampicillin (55.1%), sulfamethoxazole (59.4%), trimethoprim (14.5%), and tetracycline (47.8%) were reported for 2017 (n = 69). Also, significant levels of resistance were reported in *Salmonella* spp. from fattening pigs to ampicillin (29.5%), sulfamethoxazole (34.1%), trimethoprim (13.6%), and tetracycline (52.3%) were reported for 2017 (n = 44). Also, significant levels of resistance were found in indicator *E. coli* from fattening pigs for chloramphenicol (5.8%), ampicillin (35.5%), sulfamethoxazole (34.9%), trimethoprim (30.2%), and tetracycline (37.2%) in 2017 (n = 172). The prevalence of presumptive

ESBL- and/or AmpC-producing *E. coli* isolates from retail pig meat collected in 2017 was found to be 3.7% (*n* = 300).

Mateus *et al.* (2016) reviewed antimicrobial resistance in the food chain and noted that, for pork, Denmark reported an increase in ampicillin resistance (up to 73% in 2013) in *Salmonella* isolates and very low prevalence levels of fluoroquinolone resistance (up to 6%). All *Salmonella* isolates tested over recent years were susceptible to colistin. Ampicillin resistance was also reported to be increasing in *E. coli* isolates from Danish pork meat (up to 33% in 2012). In 2013, low prevalence levels of resistance to third generation cephalosporins (3GC) (< 1.5% to cefotaxime and ceftiofur) as well as to fluoroquinolones (< 1.4% for both nalidixic acid and ciprofloxacin) were observed in *E. coli* isolates from Danish pork meat.

There has been a concerted effort to reduce the use of antimicrobials in Danish pork in the past two decades. This has been very successful and fully detailed in a report by FAO and the Danish Veterinary and Food Administration (2019). For instance, by investing in strategies for infection prevention (i.e. improving hygiene and nutrition, and introducing improved housing facilities), it was possible to reduce the overall use of antibiotics in the swine sector by 25% since 2009 while maintaining profitability.

7.3. References for Denmark

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8. Ireland

8.1. Beef

8.1.1. Market overview

Most beef produced in Ireland is reared domestically, and only around 10% of live cattle are exported. There are a few main beef processors who dominate large portions of the market share. Ireland exports over 90% of its beef, with around 50% of this going to the UK (Power, 2020).

There are over 100,000 farms who rear cattle in Ireland, but they are not all exclusively holding bovine animals. Cattle are reared by farmers who then sell their animals to the slaughterhouses.

8.1.2. Production processes

8.1.2.1. Biosecurity

The Department for Agriculture, Farm and the Marine (DAFM) provide guidance on biosecurity which includes most standard practices employed across the EU/UK. This includes isolation of animals before entering the herd, requirements for intra-EU health certificate on purchased animals and more (DAFM, 2017 and 2018). The Teagasc Beef Manual also provides biosecurity advice which appears synonymous with advice from DAFM (Teagasc, 2016).

Information on EU regulation on biosecurity can be found in section 6.1.2.1.

8.1.2.2. Transport and slaughter

Live animals are to be transported in line with EU legislation which includes a maximum transport time of 8 hours and an appropriate lairage time at the slaughterhouse. Slaughter should comply with EU legislation with regards to stunning and killing methods. Whole or part carcasses can be transported before cutting provided that the competent

authority approves it. The meat can only be transported for a maximum of two hours if not chilled fully (FSAI, 2017).

Information on EU regulation of transport and slaughter can be found in section 6.1.2.2.

8.1.2.3. Ante and post-mortem inspection

Both ante and post-mortem inspection points should comply with Irish legislation ensuring the competent authority employs veterinary inspectors to carry out proceedings. Assistants are able to partake in inspections, but a veterinary inspector must be onsite to complete and sign off all inspections (FSAI, 2012).

8.1.2.4. Chilling and other intervention steps

A target temperature of 7°C in meat and 3°C in offal is specified by FSA Ireland. This must be achieved using a continuous cooling curve and in an environment no higher than 12°C, taking into account transport requirements if being relocated for cutting after slaughter. The meat is then to be chilled as soon as possible after cutting has taken place. There is no time limit on this step (FSAI, 2009).

In line with Article 3(2) of Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. However, carcasses or half carcasses of cattle may also be washed with recycled hot water as per Commission Regulation (EU) 2015/1474. Commission Regulation (EU) No 101/2013 permits the use of lactic acid on bovine carcases, half carcases, or quarters to reduce microbiological surface contamination but no other chemical can be used.

8.1.3. Microbiology

8.1.3.1. Microbiological criteria

As a member of the EU, beef produced in the Ireland is required to meet the requirements of Commission Regulation (EC) No 2073/2005 (see Annex 1).

8.1.3.2. Prevalence

8.1.3.2.1. *Salmonella*

A study by Khen *et al.* (2014) indicated that *Salmonella* could be found at low levels at all stages of the beef chain production, processing and retail. *Salmonella* prevalence was low throughout all sample types taken in the beef production chain: bovine hide (0.75%, 3 of 400); carcasses (0.25%, 1 of 400); and ground beef (3%, 3 of 100).

A previous report (Duggan *et al.*, 2012). Reported on results from testing done by Food Business Operators in Ireland between 2005 to 2009. This reported a prevalence of *Salmonella* in raw bovine meat of 0.1%. The type of meat tested and the point in the production/distribution chain were not specified.

Table 13: Ireland, Beef – Crude prevalence rates for *Salmonella* species in raw meat and raw meat products, 2005-2009. Number of positive/number of tested products.

Sample type	2005	2006	2007	2008	2009
Ovine	3/2,773 (0.5)	2/2,212 (0.09)	2/2,183 (0.09)	1/2,267 (0.04)	3/2,195 (0.1)
Bovine	40/26,977 (0.15)	47/33,135 (0.14)	25/35,134 (0.07)	55/26,975 (0.2)	35/27,540 (0.1)

Source: Duggan *et al.*, 2012

A survey undertaken by FSAI (FSAI, 2013) investigated the prevalence of *Salmonella* and verotoxigenic *Escherichia coli* (VTEC) in samples of raw minced beef and raw beef burgers from retail outlets and catering premises in Ireland. *Salmonella* (identified as *Salmonella* Dublin) was detected in 0.1% of samples (1/983).

8.1.3.2.2. *Campylobacter*

There is not a great amount of information in the recent published literature. A survey of retail foods in Ireland (Whyte *et al.*, 2004) noted a prevalence of *Campylobacter* in raw beef of 3.2% (7 positives of 221 samples) was reported.

8.1.3.2.3. STEC

Data on STEC prevalence in Irish beef was collated by FSAI and reported in 2019 (FSAI, 2019). A summary of the findings is presented in the table below.

Table 14: Ireland, Beef – Summary of studies investigating STEC prevalence

Year of sampling	Matrix	Methodology	Number of samples	Serogroup examined	STEC	Reference
1997–1998	Beef carcass at slaughter plant	Culture method to isolate *E. coli* O157 followed by PCR to confirm virulence genes	250	O157	STEC O157: 0%	McEvoy *et al*., 2003
2001–2002	Retail minced beef and beef burgers	Culture method to isolate *E. coli* O157 followed by PCR to confirm virulence genes	1,533	O157	STEC O157: 2.8%	Cagney *et al*., 2004
2001–2004	Beef carcass at slaughter plant	Culture method to isolate *E. coli* O157 followed by PCR to confirm virulence genes	132	O157	STEC O157: 3%	Carney *et al*., 2006
2004	Retail minced beef	Culture method to isolate *E. coli* O26 and O111 and	800	O26, O111	STEC: 0%	Murphy *et al*., 2005

Year of sampling	Matrix	Methodology	Number of samples	Serogroup examined	STEC	Reference
		PCR to confirm virulence genes				
2007–2008	Beef carcass at slaughter plant	Screened by real-time PCR for *stx*1 and *stx*2, followed by sero-specific real-time PCR. Isolates cultured from PCR-positive samples.	*n*=301 carcass swabs analysed for O157 and O111 *n*=402 carcass swabs analysed for O26, O103 and O145	O157 O26 O111 O103 O145	STEC: 1.3% 1 serotype: O157 (*n*=4)	Thomas *et al*., 2012
2010	Bovine carcass at slaughter plant	Screened by PCR for *stx*1 and *stx*2. Samples PCR positive for *stx*1 and/or *stx*2 were cultured for STEC detection.	450	Strains isolated from *stx*-positive samples serotyped and examined for the presence of genes associated	STEC: 1.1% 4 serotypes: O13:H2 (*n*=1) O26:H11 (*n*=2) O113:H4 (*n*=1) O168:H8 (*n*=1)	Monaghan *et al.*, 2012

Year of sampling	Matrix	Methodology	Number of samples	Serogroup examined	STEC	Reference
				with virulence		
2012	Beef and sheep minced meat and minced meat products	Not stated	Beef samples (*n*=172) Sheep samples (*n*=70)	O156 O26 O111 O103 O145	0%	Yearsley *et al*., 2011

Source: FSAI, 2019

Prendergast *et al.* (2011) noted a prevalence of *E. coli* O157 in beef carcass swabs of 3.9% (STEC was not tested).

8.2. Lamb

8.2.1. Market overview

The main counties in Ireland who rear sheep are Donegal, Galway and Mayo (DAFM, 2019). According to the December 2019 Livestock Survey, there are 3.8 million sheep in Ireland, 2.7 million of which are breeding ewes. This in comparison to 6.6 million cattle (CSO, 2020). These sheep are formed of 34,000 flocks, around 67% of which contain less than 100 ewes (Teagasc, 2016). France is the main importer of Irish lamb at around 33%, following by the UK at around 20% (Keady *et al*., 2016).

8.2.2. Production processes

8.2.2.1. Biosecurity

The guidance offered by DAFM is the same for beef and lamb, for more information see section 8.1.2.1.

Information on EU regulation on biosecurity can be found in section 6.1.2.1.

8.2.2.2. Transport and slaughter

Requirements for transport and slaughter are the same for beef and lamb, for more information see section 8.1.2.2.

Information on EU regulation of transport and slaughter can be found in section 6.1.2.2.

8.2.2.3. Ante and post-mortem inspection

Requirements for ante and post-mortem inspection are the same for beef and lamb, for more information see section 8.1.2.3.

8.2.2.4. Chilling and other intervention steps

A target temperature of 7°C in meat and 3°C in offal is specified by FSA Ireland. This must be achieved using a continuous cooling curve and in an environment no higher than 12°C, taking into account transport requirements if being relocated for cutting after

slaughter. The meat is then to be chilled as soon as possible after cutting has taken place. There is no time limit on this step (FSAI, 2009).

In line with Article 3(2) of Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. However, carcasses or half carcasses of sheep may also be washed with recycled hot water as per Commission Regulation (EU) 2015/1474. Additional chemicals may not be used.

8.2.3. Microbiology

8.2.3.1. Microbiological criteria

As a member of the European Union, Ireland is governed by EU law i.e. Commission Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs (Annex 1).

8.2.3.2. Prevalence

8.2.3.2.1. *Salmonella*

A report by Duggan *et al.* (2012) noted results from testing undertaken by Food Business Operators in Ireland between 2005 to 2009. The type of meat tested and the point in production/distribution chain were not specified.

Table 15: Ireland, Lamb – Crude prevalence rates for *Salmonella* species in raw lamb and lamb products, 2005-2009

Sample type	2005 No. positive/ No. tested (%)	2006 No. positive/ No. tested (%)	2007 No. positive/ No. tested (%)	2008 No. positive/ No. tested (%)	2009 No. positive/ No. tested (%)
Ovine	3/2,773 (0.5)	2/2,212 (0.09)	2/2,183 (0.09)	1/2,267 (0.04)	3/2,195 (0.1)

Source: Duggan *et al.*, 2012

8.2.3.2.2. *Campylobacter*

Whyte *et al.* (2004) published a paper on the occurrence of *Campylobacter* in retail food in Ireland. This reported that tests on 262 retail lamb samples and noted 31 *Campylobacter* positives giving a prevalence of 11.8%.

8.2.3.2.3. STEC

Data on STEC prevalence in Irish lamb was collated by FSAI and reported in 2019 (FSAI, 2019) (quoting the paper of Lenahan *et al.*, 2007). It should be noted that the initial parts of this test were aimed at detecting *E. coli* O157, isolates of which were then further tested to determine the presence of *stx* genes. The method would not have detected non O157 STEC.

A summary of the results is given in the Table 16.

Table 16: Ireland, Lamb – Summary of studies investigating STEC prevalence in Irish lamb

Year	Sample type	Method	Sample number	Results
2005-2006	Lamb carcasses at slaughter	Culture method to isolate *E. coli* O157 followed by PCR to confirm virulence genes	Pre-chill carcass swabs (*n*=400) Post-chill carcass swabs (*n*=400)	STEC O157 (*n*=7; 0.9%) *E. coli* (*stx*−) O157:H7 (*n*=10; 1.25%) Pre-chill (*n*=6) Post-chill (*n*=4)

Lenahan *et al.* (2007) reported a prevalence of *E. coli* O157 in pre and post chill carcasses or 1.5% and 1% respectively (*n* = 400 in both cases) whilst Prendergast *et al.* (2011) reported a prevalence of *E. coli* O157 in lamb carcass swabs of 2.9% (*n* = 407) (STEC was not tested in either case).

8.3. Antimicrobial resistance

EU policies on monitoring and restricting use of antibiotics in animals are followed by Ireland. As a member of the EU, Ireland will implement the EU One Health Action Plan against Antimicrobial Resistance (AMR) (EC, 2017). For this purpose, the Department of Health has published Ireland's National Action Plan on Antimicrobial Resistance 2017-2020 (DoH, 2017).

In 2022, new legislation, Regulation (EU) 2019/4 and Regulation (EU) 2019/6, prohibiting all forms of routine antibiotic use for prophylaxis and growth promotion in farming within the EU will come into force.

Data from the European Medicines Agency (EMA, 2020) on the sales of veterinary antimicrobials in Europe suggests that, for the 25 countries which provided sales data for all years between 2011 and 2018, an overall decline in sales of antibiotics for use in animals (in mg/PCU) of 34.6% was observed. For Ireland, the EMA report indicated a rather stable level of use – the annual sales of veterinary antimicrobial agents for food producing species decreased merely from 51.5 mg/PCU in 2010 to 46.0 mg/PCU in 2018 (twelfth-lowest among 31 countries covered). The latest figure is greater than that in the UK (by 56%) and Denmark (by 21%), but lower than in the Netherlands (by 25%) and Poland (by 264%).

O'Neill (2015) ranked Ireland as the twelfth-lowest for antibiotic use in agriculture among the 29 countries examined at the time of the review.

As noted in section 6.5, Annually within the EU, the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control (ECDC) collect, analyse and publish data on antimicrobial resistance in EU member states (EFSA and ECDC, 2020). For Ireland, the report did not provide any data on the prevalence of antimicrobial resistance related to beef or lamb other than that the prevalence of presumptive ESBL- and/or AmpC-producing *E. coli* isolates from retail bovine meat collected in 2017 was found to be 0.7% (n = 300).

A paper published in 2020 (Martin *et al.*, 2020) reviewed antimicrobial use in farm animals in Ireland. For beef, the only research available on the topic has quantified use in calf-rearing systems. No data were available to estimate the overall quantities of

antimicrobials used in the beef industry in Ireland. For sheep industry, there were no data available to estimate the quantities of antimicrobials used, neither at an overall level nor within a particular age group or specific use. This paper did note a deficit of knowledge in antimicrobial use at the sector level in farmed animals in Ireland.

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9. Netherlands

9.1. Lamb

9.1.1. Market overview

Around 37,000 sheep/goat farms were registered in the Netherlands at the end of 2018, however, this figure is not split into sheep or goats. Figures from the Multi Annual National Control Plan for the Netherlands show there are around 10 times as many sheep businesses than goats so it may be that the majority of these farms are for sheep. At the end of 2018 there were 184 slaughterhouses for red meat, around 700,000 sheep/goat/deer and other ruminants were slaughtered (NVWA, 2017).

9.1.2. Production processes

9.1.2.1. Biosecurity

Information on EU regulation on biosecurity can be found in section 6.1.2.1.

9.1.2.2. Transport and slaughter

Information on EU regulation of transport and slaughter can be found in section 6.1.2.2.

The Netherlands Food and Consumer Product Safety Authority (NVWA) is responsible for supervising the welfare of animals kept for commercial purposes, including at slaughter.

Rules on the transport of live animals are intended to protect animal welfare. There are rules on journey and rest times, the professional competence of drivers and technical requirements for the vehicle. The NVWA can undertake enforcement actions including fines and suspension or withdrawal of the transport company's licence.

9.1.2.3. Ante and post-mortem inspection

Ante-mortem inspection is performed by an official veterinarian (OV) with assistance from an auxiliary who may perform routine daily tasks. The final decision on suitability for

slaughter lies with the OV. If emergency slaughter is necessary, an animal does not have to be transported to the slaughterhouse for inspection, but specific guidelines have been provided for how this should be performed. If the meat passes post-mortem inspection by an OV then it may enter the food chain. Post-mortem inspection is the responsibility of an OV, with an auxiliary's assistance.

9.1.2.4. Chilling and other intervention steps

The Netherlands follows EU requirements for chilling and washing of carcasses, i.e. meat should be chilled down to below 7°C as soon as possible, offal to 3°C.

In line with Article 3(2) of Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. However, carcasses or half carcasses of sheep may also be washed with recycled hot water as per retained Commission Regulation (EU) 2015/1474. Additional chemicals may not be used.

9.1.3. Microbiology

9.1.3.1. Microbiological criteria

As a member of the EU, the Netherlands complies with the microbiological criteria of the European Union (Annex 1).

9.1.3.2. Prevalence

9.1.3.2.1. *Salmonella*

Data on prevalence of *Salmonella* in lamb in the Netherlands was reported by the National Institute for Public Health and the Environment (RIVM, 2018).

Table 17: The Netherlands, Lamb – *Salmonella* prevalence in lamb by year

Meat type	2006-2012 *n*=881	2013 *n*=52	2014 *n*=31	2015 *n*=40	2016 *n*=112	2017 *n*=196
Lamb	0.5%	0%	0%	0%	1.8%	1%

9.1.3.2.2. *Campylobacter*

A report (Anon, 2012) indicated a prevalence of *Campylobacter* in retail fresh lamb as being 2.2%, in this case the number of samples tested was not reported.

9.1.3.2.3. STEC

No information could be found on the prevalence of STEC in lamb in the Netherlands.

9.2. Pork

9.2.1. Market overview

Around 12,000 pig farms were registered in the Netherlands as of 2018, 15.5 million pigs were slaughtered in 2018; this was performed across 184 red meat slaughterhouses (NVWA, 2017).

9.2.2. Production processes

9.2.2.1. Biosecurity

Information on EU regulation on biosecurity can be found in section 6.1.2.1.

The Netherlands borders on Belgium who have had cases of African Swine Fever (ASF) in recent years. Therefore, there is a drive to ensure this does not move across the border. The NVWA has made efforts to inform and protect producers to ensure outbreaks can be contained if possible (NVWA, 2017).

9.2.2.2. Transport and slaughter

Transport and slaughter requirements are the same for lamb and pork, see section 9.1.2.2 for more details.

Information on EU regulation of transport and slaughter can be found in section 6.1.2.2.

9.2.2.3. Ante and post-mortem inspection

Ante and post-mortem inspection requirements are the same for lamb and pork, see section 9.1.2.3 for more details.

9.2.2.4. Chilling and other intervention steps

The Netherlands follows EU requirements for chilling and washing of carcasses, so meat should be chilled down to below 7°C as soon as possible, offal to 3°C.

In line with Article 3(2) of Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. However, carcasses or half carcasses of pigs may also be washed with recycled hot water as per Commission Regulation (EU) 2015/1474. Additional chemicals may not be used.

9.2.3. Microbiology

9.2.3.1. Microbiological criteria

As a member of the EU, the Netherlands complies with the microbiological criteria of the European Union (Annex 1).

9.2.3.2. Prevalence

9.2.3.2.1. *Salmonella*

Berends *et al.* (1998) considered *Salmonella* prevalence on Dutch pork and estimated that in butchers' shops primal cuts and retail-ready pork will have a *Salmonella* prevalence of 25% to 30% and that the estimated prevalence in minced pork and sausages is at 50% to 55%. These estimates were based on the observed variation in incidence in minced pork and sausages, together with practical methodological variations in test methods (i.e. different methodologies used in testing pork via swabbing, and pork products via sampling whole pieces of meat) and combining this with consideration of cross contamination during meat handling therefore assuming that, as the pork is increasingly handled, it will become more highly contaminated. Berends *et al.* (1998) refer to their figures as an assumption based on available data and knowledge of test methods and meat handling.

In 2008, EFSA published a report on *Salmonella* in pigs in the EU. This did report prevalence data but only for lymph nodes in Dutch pigs (92 out of 1,087 positive) giving a prevalence of 8.5%.

EFSA and ECDC (2015) reports on *Salmonella* in pork (there is no definition as to whether this is at slaughter, cutting plant or retail). The prevalence was 0.56% (4 positives in 708 samples).

EFSA country reports for 2018 note that for fresh retail pork, there was a prevalence of 1.2% (4 positives from 313 samples).

9.2.3.2.2. *Campylobacter*

A study by EFSA and ECDC (2015) reports a 0.44% prevalence (3 positive samples out of 686) in fresh pork in the Netherlands.

9.2.3.2.3. STEC

A report by EFSA and ECDC (2015) gave information on faecal monitoring of pigs. They found 15.9% positive (29 out of 183 samples), none were *E. coli* O157, but other serogrouping was not done. This does not of course mean that the meat from such animals would be positive, as good slaughter hygiene would prevent carcass contamination.

EFSA (2018) country reports for 2018 note that for retail pork prevalence was 0.69% (1 positive from 143 samples). The test used was for STEC, but no serogroup was specified.

9.2.3.2.4. *Trichinella*

As the Netherlands is a Member State of the EU, sampling and testing for *Trichinella* falls under Commission Implementing Regulation (EU) 2015/1375.

In 2018, no *Trichinella* positives were found in Netherlands (EFSA and ECDC, 2019).

9.3. Poultry

9.3.1. Market overview

The Netherlands produces 1.16 million tonnes of poultry meat. Its exports of poultry meat are higher at >1.4 million tonnes, the difference due to poultry meat that is imported then exported again.

9.3.2. Production processes

In the broiler section, three companies own the majority of the pure-bred lines. The following overview is provided by the industry: Breeding farms have to have high levels of biosecurity to prevent contamination with diseases. At the broiler farms, chicks are kept in cleaned sheds for 6-10 weeks. Official documents concerning the flock (e.g. disease history) are sent with the chicks to the slaughterhouse. This is checked before arrival to ensure that the chicks can be accepted. The chicks are checked before and after slaughter. An official veterinarian is on-site at all times during the slaughtering process. During processing, microbiological criteria are complied with and frequent audits are carried out by the competent authorities. Strict hygiene requirements are also complied with as laid out in EU and national legislation. Tracking systems ensure that meat can be traced back to the source farm (Holland Poultry, Production chain).

A review of official controls was undertaken in 2017 (DG Santé, 2017a). This indicated that Agencies are in charge of organisation of official controls according to the ministries' policies and supervision on independent administrative public bodies. Agencies act as competent authorities centrally located in the country. Independent administrative public bodies are in charge of execution of official controls at regional level following the agencies programmes.

Following the horse meat scandal in 2012, the Dutch Minister of Health, Welfare and Sport and the Dutch Minister for Agriculture established the Food Confidence Task Force in March 2013. This task force, working in cooperation with the Netherlands Food and Consumer Product Safety Authority (NVWA), defined a set of criteria for quality schemes

in order to strengthen the private safeguarding of food safety and especially food integrity. A list of those schemes accepted is provided (Ketenborging, 2020).

In the Netherlands, the scheme offered by the poultry industry representative body, IKB Kip supply chain quality scheme for the poultry meat sector, covers all stages of production (from breeding to processing) (Pluimned, 2020). Participation in the scheme is voluntary. While the IKB Kip scheme covers almost 100% of the Dutch poultry meat sector, it is not yet fully accepted by the government – according to the last updated list published (2018) the acceptance of the quality scheme is still under discussion. Similarly, Global G.A.P. is not yet accepted. Schemes that are accepted include BRCGS Food, FSSC 22000 and IFS. The members of such accepted quality schemes are potentially subject to reduced extent and frequency of official controls by NVWA.

It is commented that establishments exporting poultry meat abroad usually seek to attain BRCGS Food certification which is accepted by the government.

9.3.2.1. Biosecurity

The Netherlands' Ministry for Economic Affairs has guidance on outbreaks of avian influenza as well as advice on controlling zoonotic diseases (Bruschke, 2017).

GD Animal Health is commissioned by the Dutch Ministry of Economic Affairs and Climate Policy (EZK) and industry/umbrella organisations to monitor the health of all farm animals in the Netherlands. The NVWA bases the certification of the health status of animals and holdings on the tests performed by the GD Animal Health. The reports of monitoring results are managed and published by ChainPoint through a database named AVINED, and GD Animal Health (AVINED, date not specified; Royal GD, 2020).

Information on EU regulation on biosecurity can be found in section 6.1.2.1.

9.3.2.2. Transport and slaughter

Information on EU regulation of transport and slaughter can be found in section 6.1.2.2.

9.3.2.3. Ante and post-mortem inspection

An OV checks the carcasses and viscera, or this can be undertaken by competent staff upon completion of appropriate training.

9.3.2.4. Chilling and other intervention steps

Legislation does not define a chilling time, just that the final meat temperature must be below 4°C before transport or cutting. Mostly air chilled, the EU recommends a minimum of 4.5% moisture absorbed by the carcass during water immersion chilling and 2% for air chilling.

In line with Article 3(2) of retained Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. Additional chemicals may not be used.

9.3.3. Microbiology

9.3.3.1. Microbiological criteria

As a member of the European Union, the Netherlands is governed by EU law i.e. Commission Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs (Annex 1).

GD Animal Health is commissioned by the Dutch Ministry of Economic Affairs and Climate Policy (EZK) and industry/umbrella organisations to monitor the health of all farm animals in the Netherlands. The NVWA bases the certification of the health status of animals and holdings on the tests performed by the GD Animal Health. The reports of monitoring results are published by AVINED and GD Animal Health (AVINED, date not specified; Royal GD, 2020).

In 2013, a report from the Netherlands National Institute for Public Health and the Environment (RIVM) on Microbiological criteria for *Campylobacter* first noted that setting a critical limit of 1,000 cfu/g *Campylobacter* would reduce human illness cases by 66% (Swart *et al.*, 2013).

9.3.3.2. Prevalence

9.3.3.2.1. *Salmonella*

Data on Netherlands poultry flocks can be obtained from EFSA baseline surveys. Data from 2008 survey (EFSA, 2010) shows that *Salmonella* levels in carcasses were at a level of 10%.

The Netherlands also maintain a database of *Salmonella* laboratory test-results, but this is not publicly available (AVINED National plan, 2019).

Monitoring for zoonotic *Salmonella* at breeding and laying poultry farms, zoonotic *Salmonella* infections were established on 31 poultry farms in 2017 (29 in 2016). Twenty-nine of these cases involved laying poultry farms. The other two cases involved the breeding parent flock, with the NVWA tracking a suspected infection back to these birds based on the use of antibiotics at the farm. Monitoring of breeding poultry farms did not detect any zoonotic *Salmonella* infections in 2017 (NVWA, 2017).

The latest available data (October 2020) published by GD shows 7 laying flocks reporting as positive for zoonotic salmonellosis from the nationwide monitoring programme.

9.3.3.2.2. *Campylobacter*

Campylobacter levels from the above baseline survey (EFSA, 2010) indicated the Netherlands as having a contamination rate in broiler carcasses of 37.6%. Monitoring data is quoted as “No data available” in the latest GD monitoring report in which it is mentioned (July 2020).

9.4. Antimicrobial resistance

EU policies on monitoring and restricting use of antibiotics in animals are followed by the Netherlands. As a member of the EU, the Netherlands will implement the EU One Health Action Plan against Antimicrobial Resistance (AMR) (EC, 2017; Government of the Netherlands, 2015).

In 2022, new legislation, Regulation (EU) 2019/4 and Regulation (EU) 2019/6, prohibiting all forms of routine antibiotic use for prophylaxis and growth promotion in farming within the EU will come into force.

Data from the European Medicines Agency (EMA, 2020) on the sales of veterinary antimicrobials in Europe suggests that, for the 25 countries which provided sales data for all years between 2011 and 2018, an overall decline in sales of antibiotics for use in animals (in mg/PCU) of 34.6% was observed. For the Netherlands, the EMA report indicated a considerable drop in annual sales of veterinary antimicrobial agents for food producing species – from 146.1 mg/PCU in 2010 to 57.5 mg/PCU in 2018 (fifteenth-highest among 31 countries covered). The latest figure is greater than that in the UK (by 95%), Denmark (by 50%), and Ireland (by 25%), but lower than in Poland (by 191%)

The use of antimicrobials in animals was the subject of a DG Santé audit (DG Santé, 2017b) which concluded that a number of measures had been put in place to encourage the prudent use of antibiotics. It also noted a very significant reduction in the use of antibiotics in animals in the Netherlands (58.4% decrease in sales from 2009 to 2015).

O'Neill (2015) ranked the Netherlands as the thirteenth-highest for antibiotic use in agriculture among the 29 countries examined at the time of the review.

As noted in section 6.5, annually within the EU, the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control (ECDC) collect, analyse and publish data on antimicrobial resistance in EU member states (EFSA and ECDC, 2020). For the Netherlands, significant levels of resistance in *Salmonella* spp. from fattening pigs to chloramphenicol (10%), ampicillin (76%), colistin (6%), sulfamethoxazole (68%), trimethoprim (16%), and tetracycline (58%) were reported for 2017 (n = 50). *C. coli* isolates from fattening pigs had resistance to streptomycin (73.5%), nalidixic acid (15.7%), ciprofloxacin (15.7%), erythromycin (6%), and tetracycline (88%)

in 2017 (*n* = 83) but the sample origin was not reported. Also, significant levels of resistance were found in indicator *E. coli* from fattening pigs for chloramphenicol (12.3%), ampicillin (22%), sulfamethoxazole (34.3%), trimethoprim (30.7%), and tetracycline (42.7%) in 2017 (*n* = 300).

For poultry, the report noted significant levels of resistance in *Salmonella* spp. from carcasses of broilers to gentamicin (14.3%), ampicillin (23.8%), tigecycline (19%), nalidixic acid (61.9%), ciprofloxacin (61.9%), sulfamethoxazole (61.9%), trimethoprim (61.9%), and tetracycline (33.3%) for 2018 (*n* = 21). Significant levels of resistance in indicator *C. jejuni* from broilers were also reported for streptomycin (10.3%), nalidixic acid (66.7%), ciprofloxacin (70.5%), and tetracycline (64.1%) in 2018 (*n* = 156). Indicator *C. coli* isolates from broilers had resistance to streptomycin (4.8%), nalidixic acid (77.4%), ciprofloxacin (77.4%), erythromycin (4.8%), and tetracycline (69.4%) in 2018 (*n* = 62). Also, significant levels of resistance were found in indicator *E. coli* from broilers for chloramphenicol (20.1%), ampicillin (31.6%), ciprofloxacin (5.3%), sulfamethoxazole (34.9%), trimethoprim (28.2%), and tetracycline (57.9%) in 2018 (*n* = 209).

The prevalence of presumptive ESBL- and/or AmpC-producing *E. coli* isolates from broiler meat collected in 2018 and from retail pig meat collected in 2017 was found to be 14.1% (*n* = 291) and 1.1% (*n* = 273), respectively.

The EFSA and ECDC report did not specifically address antimicrobial resistance in isolates from lamb.

The Netherlands livestock industry must comply with strict rules on antibiotic use:

- Antibiotics may only be prescribed by a veterinarian;
- Veterinarians must inspect and assess a farm before prescribing antibiotics to sick animals;
- Farmers may only administer antibiotics themselves under strict conditions;
- Livestock farmers must register all the antibiotics they use, to show how much each animal receives. The Netherlands Veterinary Medicines Institute (SDa), which sets rules for responsible antibiotic use, collects this information;
- ‘Last-resort’ antibiotics for humans may only be administered to sick livestock under strict conditions;
- Farmers may not deliver animals for slaughter that contain antibiotic residues.

The Netherlands Food and Consumer Product Safety Authority (NVWA) monitors the registration and use of antibiotics by farmers. Information on AMR monitoring is used by the Health Council of the Netherlands in drafting advisory documents, to assess risks and develop policies on the reduction of antimicrobial usage and to develop AMR monitoring strategies. As a consequence of this process, the AMR monitoring plan focuses extensively on testing for extended-spectrum β-lactamases (ESBL) and carbapenemases-producing bacteria in relevant foods to assess consumer exposure.

A report by DG Santé (2017a) concluded that the competent authority has had in place, well before the inception of Decision 2013/652/EU, an extensive AMR monitoring plan fully integrated in a wider AMR policy and underpinned by a good performing laboratory network. In most areas the plan goes significantly beyond the minimum EU requirements, notably, regarding the number of samples taken, the frequency of sampling, and the combinations of species and foods to be covered.

A recent review conducted for the FSA (Mateus *et al.*, 2016) considered AMR in various meats, including pork and poultry, from some countries. The report noted that, in the Netherlands, surveillance data available for pork focused on commensal bacteria and that very low prevalence of resistance to ampicillin (between 0.1 and 2%) was observed in isolates from pork. Higher resistance levels to erythromycin in *E. faecalis* and *E. faecium* isolates were detected (15% and 41.4%, respectively). No vancomycin resistant *Enterococci* isolates were observed. In *E. coli*, a decrease in ampicillin resistance was noted down to 12.7% in 2014 from 34% in 2006. Low levels of resistance to third generation cephalosporin antimicrobials were also detected (1.6% cefotaxime) in *E. coli* isolates from pork but no resistance to meropenem was observed in 2014. A slight increase was noted in fluoroquinolone resistance but remained low (< 3%). Very low resistance was also reported to azithromycin (0.9%).

For poultry, high levels of resistance to ciprofloxacin and nalidixic acid (at 63.4% in 2014) and low level of resistance to erythromycin (0.7%) were detected in *C. jejuni* isolates from poultry meat. In commensal bacteria, low levels of ampicillin resistance (1.8%) and an increase of erythromycin resistance to 51.8% were reported in *E. faecalis* isolates from Dutch poultry in 2013. On the other hand, a sharp decrease in ampicillin resistance in *E. faecium* isolates from Dutch poultry meat was observed between 2002 and 2013 (from 16% down to 6%). In *E. coli*, ampicillin resistance was down to 40.7% in chicken meat in

2014. The report also indicates that cefotaxime resistance has also decreased since 2002, down to 1.9%. Colistin resistance in chicken meat was reported at 1.5%.

While the Netherlands compile extensive annual surveys of antimicrobial use and resistance, data in the latest or earlier MARAN reports contain no specific information on Dutch lamb. Instead, the numbers are for fresh lamb or sheep meat produced in the EU. In 2019, only 2 out of 238 samples of fresh lamb meat were suspected to contain ECBL/AmpC-positive *E. coli* (MARAN, 2020).

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10. Poland

10.1. Poultry

10.1.1. Market overview

Poland is the EU's largest poultry meat producer, processing 2.2 million tonnes of which 1.34 million tonnes is exported. It exports around 60% of its chicken meat to other EU countries but has experienced a drop in production over 2019 due to outbreaks of highly pathogenic avian influenza. Broilers account for 85% of production, and the rest is predominantly turkey (FAS, 2020).

The National Poultry Council – Chamber of Commerce represents the poultry industry in Poland. In addition, they also conduct activities in the field of poultry breeding and assessment under delegated authority from the Minister of Agriculture and Development of Rural Areas (KRD-IG).

10.1.2. Production processes

10.1.2.1. Biosecurity

Information on EU regulation on biosecurity can be found in section 6.1.2.1.

10.1.2.2. Transport and slaughter

Information on EU regulation of transport and slaughter can be found in section 6.1.2.2.

10.1.2.3. Ante and post-mortem inspection

In a DG Santé audit on Polish poultry processors, it was found that ante and post-mortem inspection was being performed in line with EU requirements. Ante-mortem inspection was performed both at the farm and upon arrival to the slaughterhouse. Relevant documents, including food chain information and health certificate, were provided and welfare checks on the birds were performed. The official controls in the establishments are performed by the Powiat Veterinary Inspectorates. According to Polish legislation, the Powiat Veterinary Inspectorates (DVI) can appoint additional staff, Authorised Veterinarians (AV), who are veterinarians not employed by the VI, to perform certain

tasks if the official staff cannot perform these tasks due to financial or organisational reasons. Specific daily controls at establishment level are performed by the AVs.

The main official control tasks carried out by AVs in establishments are:

- ante-mortem inspection and issuing health certificates at the holding;
- carrying out ante-mortem and post-mortem inspection at the slaughterhouse (including official controls on animal welfare at the time of unloading and killing);
- performing controls on the sanitary operation (e.g. pre-operational and operational hygiene controls in establishments) and on the procedures based on HACCP principles.

In the districts visited, the periodic controls/audits in the establishments were carried out by the permanently employed food safety officials from DVIs. Their tasks include supervision of the AVs (DG Santé, 2019).

Another audit focusing on slaughter shows high compliance with Regulation (EC) No 1099/2009 when considering animals sent for slaughter. This covers both welfare and poultry unfit for slaughter (DG Santé, 2015). There was a recent case of illegally slaughtered meat in Poland when a slaughterhouse deemed sick animals appropriate for slaughter. The meat was tested and found to be safe for human consumption but was withdrawn from sale due to the circumstances in which it was processed. As a result, Poland increased the number of unannounced inspections performed in all slaughterhouses (Government of Poland, 2019).

10.1.2.4. Chilling and other intervention steps

Poland follows the requirements of the EU and thus the temperature of the meat during cutting, boning, trimming, slicing, dicing, wrapping and packaging is maintained at not more than 4°C by means of an ambient temperature of 12°C or an alternative system having an equivalent effect.

In line with Article 3(2) of retained Regulation (EC) No 853/2004, only potable water or clean water may be used to remove surface contamination from products of animal origin. Additional chemicals may not be used.

10.1.3. Microbiology

10.1.3.1. Microbiological criteria

As a member of the European Union, Poland is governed by EU law i.e. Commission Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs (Annex 1).

Each FBO is responsible for developing its own sampling plan and conducting analytical tests. If required corrective actions should then be undertaken according to provisions contained in their HACCP plans.

Annual sampling plans are also conducted by the District Veterinary Inspectorate (DVIs) in order to verify the implementation of the FBOs own check sampling procedures. The DVIs also undertake a microbiological sampling plan in poultry meat establishments consisting of a number of samples equal to 10% of the samples that should have been undertaken by the FBO under the recognised programme.

10.1.3.2. Prevalence

10.1.3.2.1. *Salmonella*

Results are published as part of the Poland Zoonoses report (EFSA, 2018).

In 2011, an EFSA baseline survey of *Salmonella* in poultry across the EU was published (EFSA, 2010) and looked at data across the EU collected in 2008. The level reported in Poland is given in Table 18.

Table 18: Poland, Poultry – *Salmonella* in poultry: EFSA baseline survey 2008

Parameter	Samples tested (*n*)	Samples positive	% Positive	Number of different serovars reported
Salmonella	419	107	25.5	11

Source: EFSA, 2010

A report published in 2018 covering *Salmonella* prevalence in broilers between 2014 and 2016 investigated 4331 samples. The prevalence of *Salmonella* spp. in broiler chickens decreased from 2.19% in 2014 to 1.22% in 2016 (Witkowska *et al.*, 2018).

Poland was one of four European countries that did not meet the flock prevalence target of maximum 1% during the period 2016-2018. In breeding flocks This was exceeded twice, and the overall flock prevalence was reported as 1.30%. In broiler flocks the percentage reported positive for the *Salmonella* target serovars was 3.13% as reported by the Competent Authority and 0.08% reported by the Food Business Operator (EFSA, 2018).

10.1.3.2.2. *Campylobacter*

EFSA (2010) included a comparison between the notification rate of human campylobacteriosis and the prevalence of *Campylobacter*-colonised broiler batches and *Campylobacter*-contaminated broiler carcasses, in the EU. This indicated:

Table 19: Poland, Poultry – *Campylobacter* contaminated carcasses

Parameter	Number of Carcasses	% prevalence
Detection test	419	78.9
Combined detection and enumeration test	419	80.4

Note that both detection (presence or absence) and enumerative tests were done on samples. Sometimes these can lead to differing results (enumeration tests can be positive when presence or absence are negative)- hence the second line of the table.

Within this study enumerative testing was undertaken to establish numbers per carcass:

Table 20: Poland, Poultry – Level of *Campylobacter* presence per carcass, number per (cfu/g)

Parameter	<10 cfu/g	10-39 cfu/g	40-99 cfu/g	100-999 cfu/g	1,000-10,000 cfu/g	>10,000 cfu/g	Total
Number of carcasses in category	98	15	16	135	122	33	419
%	23.4	3.6	3.8	32.2	29.1	7.9	100

More recent publications continue to report prevalence rates of 40 to 64% for *Campylobacter* in poultry as indicated in Table 21.

Table 21: Poland, Poultry – Prevalence rates for *Campylobacter* in poultry

Date	Prevalence	Reference
2007-2008	51.7%	Mackiw *et al.*, 2011
2009-2013	41.6%	Andrzejewska *et al.*, 2015
2009-2013	49.4%	Wieczorek & Osek, 2014
2015	60.2%	Wieczorek & Osek, 2015
2018	64%	Szosland-Faltyn *et al.*, 2018
2014-2018	53.4%	Wieczorek *et al., 2020*

10.2. Antimicrobial resistance

EU policies on monitoring and restricting the use of antibiotics in animals are followed by Poland. As a member of the EU, Poland will implement the EU One Health Action Plan against Antimicrobial Resistance (AMR) (EC, 2017). For this purpose, Poland has developed a National Antibiotic Protection Program for 2016-2020 (MZ, 2016).

In 2022, new legislation, Regulation (EU) 2019/4 and Regulation (EU) 2019/6, prohibiting all forms of routine antibiotic use for prophylaxis and growth promotion in farming within the EU will come into force. It will be applicable in the UK as a retained EU legislation.

Data from the European Medicines Agency (EMA, 2020) on the sales of veterinary antimicrobials in Europe suggests that, for the 25 countries which provided sales data for all years between 2011 and 2018, an overall decline in sales of antibiotics for use in animals (in mg/PCU) of 34.6% was observed. For Poland, the EMA report indicated a substantial increase in annual sales of veterinary antimicrobial agents for food producing species – from 126.2 mg/PCU in 2011 to 167.4 mg/PCU in 2018 (sixth-highest among 31 countries covered). The latest figure is significantly greater than that in the UK (by 467%), Denmark (by 338%), Ireland (by 264%), and the Netherlands (by 191%).

O'Neill (2015) ranked Poland as the ninth-highest for antibiotic use in agriculture among the 29 countries examined at the time of the review.

As noted in 6.5, annually within the EU, the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control (ECDC) collect, analyse and publish data on antimicrobial resistance in EU member states (EFSA and ECDC, 2020).

For Poland, significant levels of resistance in *Salmonella* spp. from carcasses of broilers to ampicillin (26.6%), tetracycline (49.7%), sulfamethoxazole (51%), nalidixic acid (77.6%), and ciprofloxacin (80.4%) were reported for 2018 (*n* = 143). Significant levels of resistance in *C. jejuni* from broilers were also reported for streptomycin (31.5%), nalidixic acid (91%), ciprofloxacin (93.8%), and tetracycline (74.7%) in 2018 (*n* = 178). Also, significant levels of resistance were found in *E. coli* from broilers for chloramphenicol (23.8%), ampicillin (85.6%), nalidixic acid (64.1%), ciprofloxacin (84%), sulfamethoxazole (60.2%), trimethoprim (57.5%), and tetracycline (76.2%) in 2018 (*n* = 181).

The above is consistent with the previous reports reviewed by Mateus *et al.* (2016), who also noted multi drug resistance of up to 45% in *C. jejuni* isolates from poultry meat, but no information was provided on common phenotypes observed.

10.3. References for Poland

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11. Ukraine

11.1. Poultry

11.1.1. Market overview

Poultry export from Ukraine has seen a 20% rise from 329,000 tonnes in 2018 to 415,000 tonnes in 2019. Most poultry (60%) is processed by Myronivsky Hlebo Product (MHP). The top six companies hold 90% of the market share. Most premium parts are exported with lower grade items sold domestically. EU exports of poultry were around a third of Ukraine's output, but due to a new Tariff Rate Quota there was a drop as this quota removed loopholes previously used by Ukraine to import certain cuts and debone them in the EU, hence reducing tariffs. Total exports continue to rise into 2020.

Most poultry production is in large industrial farms, mostly broiler production at 88% of total production figures. The main large companies are vertically integrated with their own feed mills hatcheries, farms and slaughterhouses as well as growing their own feed (FAS, 2020).

11.1.2. Production processes

After using defined search criteria, little information was identified on standard production practices in Ukraine. As nearly all production is dominated by several large companies, it may be that information is less available due to competition between producers. Official sources such as DG Santé reports were the most up to date and readily available.

11.1.2.1. Biosecurity

A DG Santé report for an audit conducted in Ukraine in 2018 details how establishments conduct ante-mortem and post-mortem checks, as well as how biosecurity measures are controlled. Food chain information is supplied in the same way as the EU including results of testing, mortality rates and any medical treatments given. Procedures are in place for *Salmonella* testing before slaughter including boot swabs and these procedures are evidenced to be followed (DG Santé, 2018).

11.1.2.2. Transport and slaughter

A small issue was raised during a DG Santé audit concerning stunning currents. It was found that some slaughterhouses were using lower currents than prescribed in EU legislation to cause reversible stunning due to national requirements on Halal slaughter. These currents were justified based on studies approved by the Central Competent Authority (CCA) (DG Santé, 2018).

11.1.2.3. Ante and post-mortem inspection

National requirements require OV to carry out ante-mortem inspections both at the farm and slaughterhouse. This differs from some EU requirements which prefer OV to only inspect at the slaughterhouse to reduce risk of spreading disease from one farm to another. Veterinarians assist with inspections but the OV has the final say on if the meat is fit for human consumption (DG Santé, 2018).

On site permanent Official Veterinarians carry out official controls on a daily basis.

There are no harmonised procedures in place as regards to the control activities (i.e. no Standard Operating Procedures (SOPs), work instructions), nor is a harmonised checklist available. There is a reporting system which includes regular reports to the regional competent authority (at least once per month) by the official veterinarian on inspections (i.e. ante-mortem, post-mortem inspection) and twice per year reports are made by the regional to the central competent authority.

11.1.2.4. Chilling and other intervention steps

Information on official guidance or requirements for chilling or the use of washing agents for poultry carcasses could not be found using standard search criteria.

Rodionova & Paliy (2017) mentions the use of a standard procedure in a Ukrainian processing facility where carcasses are immersion or air chilled to below 4°C. When using immersion chilling, microbial counts found on the carcass were higher than air chilling, as found in studies related to other poultry producing countries. It would indicate that some Ukrainian facilities use 4°C as a standard chill target.

11.1.3. Microbiology

11.1.3.1. Microbiological criteria

The microbiological controls relating to poultry in the Ukraine lie under the regulatory framework of the Ministry of Healthcare of the Ukraine. In 2012, Order No. 548 of the Ministry of Healthcare was put in force. This covered microbiological criteria for establishing food safety indicators. These requirements closely match European Commission Regulation (EC) No 2073/2005 that lay down microbiological criteria regulations within the EU. Order No. 548 is compulsory for all domestically produced and imported foods and covers meat, dairy, fish, egg products, vegetable and fruit products.

There are a few criteria that do not match those of Commission Regulation (EC) No 2073/2005, and no reference can be found as to whether it is updated to include any new additional criteria that the European commission put into place. So, for example, there are no criteria set for *Campylobacter* in poultry which was a more recent addition to Commission Regulation (EC) No 2073/2005.

Order No. 548 details general food safety requirements, prohibiting the placement on the market of products considered as unsafe. Importers (food business operators) have an obligation to withdraw unsafe food from the market. Importers are required to comply with microbiological criteria provided below. This should include testing against the criteria. The testing procedure includes the taking of samples, conducting analyses and the implementation of corrective actions, in accordance with Ukraine's food law and instructions provided by State Service of Ukraine on Food Safety and Consumer Protection (SSUFSCP).

Table 22: Ukraine, Poultry – Microbiological criteria relating to poultry

Food	Organism	*M*	*c*	Criterion	Method	Products
Minced meat and meat preparations made from poultry meat intended to be eaten cooked	*Salmonella*	5	0	Absence in 25 g	EN ISO 6579	Products placed on the market during their shelf-life
Mechanically separated meat (MSM)	*Salmonella*	5	0	Absence in 10 g	EN ISO 6579	Products placed on the market during their shelf-life

Meat products made from poultry meat intended to be eaten cooked	*Salmonella*	5	0	Absence in 25 g	EN ISO 6579	Products placed on the market during their shelf-life
Raw poultry meat	*Salmonella* Typhimurium and *Salmonella* Enteritidis	5	0	Absence in 25 g	EN ISO 6579 (for detection), Kaufman-White scheme (for serotype)	Products placed on the market during their shelf-life

Source: Order No. 548
M = number of samples to be tested
c = number of test results that can exceed the criterion

Testing methods also follow those detailed in Commission Regulation (EC) No 2073/2005, with the ISO 6579 standard required for *Salmonella* testing. There is a clause allowing other methods to be used but these should be validated via ISO 16140 (also as noted in Commission Regulation (EC) No 2073/2005).

In 2018, there was a DG Santé audit on production of poultry meat and products in the Ukraine (DG Santé, 2018). This noted the use of criteria matching those in Commission Regulation (EC) No 2073/2005. It also noted that according to national legislation, only accredited laboratories (ISO 17025) can perform analyses.

Analyses of Official Samples from poultry meat and products for export to the EU are done by a network of state/regional laboratories (21 were noted in the Audit), and there was no way at that time to designate a private laboratory to undertake Official Analyses.

The Central Laboratory (the state Scientific and Research Institute for Laboratory Diagnostics and Veterinary and Sanitary Expertise) functions as a National Reference Laboratory for all diagnostic laboratories. Official samples from products to be exported to the EU are analysed in the Central Laboratory or in the regional laboratories. All these laboratories are accredited to ISO/IEC 17025 standard by the National Accreditation Agency of Ukraine (NAAU) and for microbiological analyses of products for EU export they use reference methods laid down in Commission Regulation (EC) No 2073/2005 (ISO methods).

Safety parameters for poultry meat are established by a separate regulation; Order of the Ministry of Healthcare of Ukraine of 6 June 2013 No 694 "On approval of the hygiene requirements for meat and poultry and indicators of its quality".

There is also a *Salmonella* National Control Programme. *Salmonella* sampling is carried out by the official veterinarian for each flock, 10 days before slaughter (two pairs of boot swabs pooled into one sample) and analysed in the regional official laboratory. The analyses results are communicated to the official veterinarian at the slaughterhouse.

11.1.3.2. Prevalence

11.1.3.2.1. *Salmonella*

In 2017, 3,456 samples were analysed for *Salmonella* (official and own-check samples), out of which 15 tested positive (0.43% positive rate).

One research paper was obtained (Halka *et al.*, 2019), that did cover the distribution of animal and poultry salmonellosis in Ukraine in 2015 to 2018. The data in this paper is difficult to fully interpret as whilst it quotes the number of positives, it does not give the number of samples tested (i.e. no denominator data). The paper notes that between 2015 and 2018, 865 cases of *Salmonella* detection were registered of which 230 (26.6%) were from foodstuffs and raw materials of animal origin. This report does note that during the time course of this work the number of cases of *Salmonella* detection in animal and poultry pathological materials decreased by 50% (239 to 111 cases), whilst in foods and raw materials of animal origin it increased 4 fold (from 30 to 1212 cases).

11.1.3.2.2. *Campylobacter*

Data on prevalence of *Campylobacter* in poultry products from Ukraine was not found using either Cyrillic or English terms. The DG Santé audit report states that there is a requirement for ‘Own-Check’ sampling in Ukraine, however no public presentation of this data was found.

11.2. Antimicrobial resistance

In March 2019, the beginning of an FAO project aimed at helping Ukraine to address antimicrobial resistance was announced (FAO, 2020), particularly to improve awareness on antimicrobial resistance and related threats, monitor of antimicrobial use in food and agriculture, strengthen knowledge of related authorities and promote good practices in food and agricultural systems.

It was reported that the Ukraine is committed to take steps to ensure the rational use of antimicrobials in human medicine, veterinary medicine, and food industry in accordance with best international and European practices.

The announcement noted that “FAO will support the Ministry of Agrarian Policy and Food in reducing the spread of antimicrobial resistance in the country, through help in adopting and implementing regulatory mechanisms, educational tools, efficient monitoring programmes for detecting emergence and spread of resistant strains and ensuring good hygiene and sanitation throughout the food chain”.

In 2019, Ukraine adopted a nation-wide National Action Plan to Combat Antimicrobial Resistance (Order No. 116-p of the Cabinet of Ministers of Ukraine). It aims to limit the use of antimicrobials without prescription. The objectives are the development and adoption of regulations on the control of release of antimicrobial drugs by pharmacies exclusively on prescription of veterinarians; adoption of the regulation on the use of antimicrobial drugs in veterinary medicine; development of the procedure for the implementation of epidemiological supervision over antimicrobial resistance in the field of veterinary medicine and keeping record of infectious diseases requiring medical assistance; development and approval of the use of antimicrobial drugs and data collection related to consumption of antimicrobial drugs registered in Ukraine; development and adoption of regulatory acts on the limitation of the use of antimicrobial drugs as growth stimulators in livestock, poultry and crop production; and development and review of regulatory and legal acts in the field of healthcare and veterinary medicine with a view of harmonization of the Ukrainian legislation with the legislation of the European Union in relation to the use of antimicrobial drugs used for treatment of human diseases. The goal is to make agriculture more sustainable by strengthening policies for animal health.

11.3. References for Ukraine

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12. Canada

12.1. Beef

12.1.1. Market overview

The majority of beef is exported to the US (75%), and the rest is shared between Japan, Hong Kong, Mexico, China with less than 1% being exported to the EU (FAS, 2020).

12.1.2. Production processes

There are approximately 60,000 cattle farms in Canada. Typically, the animals spend 60 – 200 days in the feedlot until they reach their optimum weight and are sold to a processor for processing into beef (CCA, 2013).

Two main processors are reported to process 85% of beef production in the country (Edmiston, 2020).

12.1.2.1. Biosecurity

The Canadian Food Inspection Agency (CFIA) has published a Beef Cattle On-Farm Biosecurity Standard which provides a structure for managing and minimising the risks of rearing cattle. The document includes sections on moving animals, people, tools, vehicles and equipment. It also has a section on managing animal health practices including creating a Herd Health Plan (HHP). Using all these tools it provides guidance on how ‘Educate, Plan, Record’ for continuous monitoring of the system (CFIA, 2016a). Livestock is subject to mandatory identification and traceability (DG Santé, 2015).

In a DG Santé report for an audit conducted in 2019, it was found that some plants were not fully adhering to rules relating to exporting beef to the EU. This was mainly focused on non-conformances related to plant hygiene and documentation involving transporting of live cattle between farm and slaughterhouse. The recommendation from DG Santé was to suspend their license to export to the EU. Since the audit work has been done to correct these actions and the export licenses remain in place. Changes made were to contracts between FBOs and CFIA veterinarians to ensure they maintain appropriate

controls or face losing their certification. There was also changes made to legislation in relation to livestock certification and traceability (DG Santé, 2020).

12.1.2.2. Transport and slaughter

Electrical, gas or captive bolt stunning, both reversible and irreversible, are permitted in Canada. Ritual slaughter rules are the same as UK/EU (CFIA, 2019a).

Under the Safe Food for Canadians Regulations (SFCR), businesses are also required to put in place preventive food safety controls to slaughter food animals from which meat products are derived as well as to manufacture, process, treat, preserve, grade, package or label food to be exported or sent across provincial or territorial borders. The SFCR require exporters to demonstrate that foods exported from Canada meet requirements such as preventive controls and traceability plans that are consistent with internationally recognised food safety controls (CFIA, 2020a; 2020b).

12.1.2.3. Ante and post-mortem inspection

Official Veterinarians (OV) are employed by the Canadian Food Inspection Agency (CFIA). Ante-mortem inspection is performed by an OV within 24 hours before slaughter, checking food chain information and the condition of the animals before slaughter. Slaughterhouse staff perform tasks such as separation and presentation of offal to assist meat inspectors (CFIA, 2018a). OV will perform post-mortem inspection and deem carcasses unsuitable as appropriate. Pieces of the carcasses may not be removed before the inspection. If a whole carcass or side (half carcass) is to be refrigerated whole, a sticker must be placed on the outside detailing the date of slaughter, and a code which corresponds to the slaughter.

Post-mortem examination is undertaken by a licence holder under the supervisions of a veterinary inspector, if an authorisation to conduct a Post-mortem Examination Program has been granted (CFIA, 2018b). Otherwise, it is inspected by an inspector (CFIA, 2019b; 2019i).

On application for a licence, CFIA will determine how many inspection stations will be needed and where. In certain conditions, the licence holder may be permitted to conduct post-mortem examination instead of post-mortem inspection conducted by an inspector.

12.1.2.4. Chilling and other intervention steps

Canada's regulations state that whole or half carcasses should be chilled in a continuous decrease in temperature over time, with the outside of the carcass reaching 7°C within 24 hours. Cut parts of primals should achieve a surface temperature of 7°C in 12 hours. In all cases the centre of the meat should then achieve 4°C in the quickest time possible, and the cooling media (air) should remain below 4°C. If carcasses/cuts need to be moved before finished chilling, for example moving primal/sub primals to a cutting plant, then HACCP controls should be in place to monitor the temperature of the carcass before, during and after transport to ensure a continuous chilling curve is present (CFIA, 2019b).

Red meat carcasses and parts can be dipped, sprayed, or washed with a wide range of permitted antimicrobials. Permitted antimicrobials include acetic acid, acidified sodium chlorite, calcium hypochlorite, chlorine dioxide, chlorine gas, citric acid, 1,3-dibromo-5,5-dimethylhydantoin, hypobromous acid, electrolytically generated hypochlorous acid, lactic acid, lactoferrin, sodium hypochlorite, ozone, sulphuric acid with sodium sulphate and a number of mixtures of these and other substances.

The substance or mixture of substances must be used in accordance with GMP and as part of an acceptable quality control program wherein such use is considered necessary to produce microbiologically safe food, is efficacious for this purpose, and is not used as a substitute for good hygienic practices. There must be no or negligible residues, including residues of reaction products, in or on the red meat product that is offered for sale so that it meets the definition of food processing aid (Health Canada, 2019).

If exporting to the EU, most chemicals may not be used, as the EU only allows washing beef with potable water, clean water, or recycled hot water. Lactic acid may be used to wash bovine carcasses, halves or quarters.

12.1.3. Microbiology

12.1.3.1. Microbiological criteria

12.1.3.1.1. *Salmonella*

The Safe Food for Canadians Regulations (SFCR) state that foods should not be contaminated and that “contaminated” means “that the food contains any micro-organism, chemical substance, extraneous material or other substance or thing that may render the food injurious to human health or unsuitable for human consumption”.

Section 47 of the SFCR does note that:

1) An operator must identify and analyse the biological, chemical and physical hazards that present a risk of contamination of a food;

2) The operator must prevent, eliminate or reduce to an acceptable level the hazards referred to in subsection (1) by using control measures that are shown by evidence to be effective, including any treatment or process and including, in the case of a meat product, the control measures that are set out in the document entitled Preventive Control Requirements for Biological Hazards in Meat Products, prepared by the Agency and published on its website, as amended from time to time (CFIA, 2018c).

For meat exports to the EU, Canadian exporters must adhere to all EU legislation including the microbiological criteria noted in Commission Regulation (EC) No 2073/2005 (CFIA, 2019d).

The European Commission, DG Health and Food Safety undertook an audit of control measures for beef and pork production in Canada in 2019 (DG Santé, 2020). In accordance with the provisions of the EU-Canada Comprehensive and Economic Trade Agreement (CETA), microbiological testing of carcasses for generic *E. coli* and *Salmonella* after chilling is carried out as described in the procedures in Annex T of the source material (CFIA, 2017) and Annex U (CFIA, 2019e) of the former MHMOP (as per United States Department of Agriculture’s performance standards). For *Salmonella* testing, 82 samples from carcasses or 53 samples from ground beef must be collected during consecutive working days, and a maximum five samples can be tested positive. For generic *E. coli*, one sample every 300 carcasses must be collected during the year.

For meat exported to the USA, requirements are noted in Annex T of the source material: Testing *E. coli* in slaughter establishments. This requires carcasses of cattle, pigs, sheep,

goats, horses etc. to be tested. The testing frequency for cattle is 1 test per 300 carcasses.

Process verification criteria are given in Table 23:

Table 23: Canada – Process verification criteria for the assessment of generic *E. coli* (biotype 1) results

Sample type	Sampling method	Number of samples in moving window (*n*)	Maximum number of marginal results (*c*)	Acceptable results	Marginal result limit (*m*)	Unacceptable result limit (*M*)
Cattle, sheep, goats & equine slaughter	Excision	13	3	Negative	Positive	10,000 cfu/cm^2
Cattle, sheep, goats & equine slaughter	Sponge	Operator must develop own system based on statistical process control	Operator must develop own system based on statistical process control	Operator must develop own system based on statistical process control	Operator must develop own system based on statistical process control	Operator must develop own system based on statistical process control
Swine at slaughter	Excision	13	3	10 cfu/cm^2 or less	10 cfu/cm^2	10,000 cfu/cm^2

Sample type	Sampling method	Number of samples in moving window (*n*)	Maximum number of marginal results (*c*)	Acceptable results	Marginal result limit (*m*)	Unacceptable result limit (*M*)
Swine at slaughter	Sponge	Operator must develop own system based on statistical process control	Operator must develop own system based on statistical process control	Operator must develop own system based on statistical process control	Operator must develop own system based on statistical process control	Operator must develop own system based on statistical process control
Chicken, ducks at slaughter	Carcass rinse	13	3	100 cfu/ml or less	100 cfu/ml	1,000 cfu/ml
Chicken, ducks at slaughter	Sponge is not applicable. The rinse method must be used	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Table 24: Canada, Beef – USDA Performance Standards for *Salmonella* by class of product

Class of product	Number of samples to be tested per set (*n*)	Maximum number of positives per set (*c*)
Steer/heifer carcasses	82	1
Cow/bull carcasses	58	2
Ground beef	53	5

Sources: Code of Federal Regulations, Ch. 9, 310.25 (7), Jan. 1st 2012; and FSIS Notice 54-12 (09/11/ 2012)

When the number of positive test results exceeds the specified "*c*" value, the establishment shall investigate the possible causes for the results (e.g. lack of adherence to the HACCP plan, procedures or CCPs which are not sufficiently effective) and draw up an action plan to correct the situation. The establishment shall communicate its findings and action plan to the V/IIC in writing within 5 working days after the "*c*" value has been exceeded. A second set of tests must then be done.

12.1.3.1.2. *Campylobacter*

No *Campylobacter* criteria were found.

12.1.3.1.3. STEC

In the CFIA preventive control plan requirements for biological hazards in meat products, incorporated by reference into the SFCR, there is a requirement to test for *E. coli* O157:H7/NM. The requirement states that the *E. coli* testing must be done in each “lot” and a 325 g sample size is used (60x5.5 g, or 5x65 g). Samples should be from the outside of the meat and a corrective action plan is required if detected (CFIA, 2018c; CFIA, 2019c).

For exports to the USA, there is a CFIA designed sampling/testing requirement for STEC for all raw boneless beef trimmings as indicated in the table below (CFIA, 2020a).

Table 25: Canada, Beef – Sampling frequency for STEC

Establishment size (production volume per year)	Normal Sampling frequency October to March	Normal Sampling frequency April to September	Normal Number of samples per year per establishment	Enhanced Sampling frequency October to March	Enhances Sampling frequency April to September
Small (<25k kg)	1 per month	1 per month	12	2 per month	2 per month
Medium (25k to 400k kg)	1 per month	3 per 2 months	15	2 per month	3 per month
Large (400k to 40M kg)	3 per 2 months	2 per month	21	3 per month	4 per month

Extra-large (>40M kg)	2 per month	4 per month	36	4 per month	8 per month

Source: CFIA, 2020a

The method of sampling is the N60 method (60 subsamples composited into one test sample of 375 g), and the test method is for *E. coli* O157, O26, O103, O111, O121, O45, and O145.

Trimmings that tested presumptive positive (that do not confirm as negative if confirmation methods are performed), and/or confirmed positive for any of the seven STEC of interest must not be exported to the USA and also will not be released into Canadian market.

12.1.3.2. Prevalence

12.1.3.2.1. *Salmonella*

A publication by Lammerding *et al.* (1988) reported on beef carcass samples tested between 1983 to 1986 had a *Salmonella* prevalence of 2.6% (*n* = 666).

A more recent publication noted that on post eviscerated, pre-chill carcasses after application of a carcass wash and/or anti-microbial interventions. Essendoubi *et al.* (2019) noted a 0.2% (*n* = 401) prevalence for *Salmonella*.

Bohaychuk *et al.* (2011) reported on carcass swabs from abattoirs in Alberta. The tested 1,036 samples of beef and found a *Salmonella* prevalence of 0.1%.

12.1.3.2.2. *Campylobacter*

In 2017, Narvaez-Bravo *et al.* considered *Campylobacter* in retail meats in Canada. They tested 145 retail samples of beef and found no *Campylobacter* positives.

Bohaychuk *et al.* (2011) also reported on *Campylobacter* prevalence on beef carcass swabs. They tested 1,022 samples with a 1.5% prevalence.

12.1.3.2.3. STEC

A review article from Health Canada (Gill, 2018) noted that a decline in the frequency in all STEC serotypes in retail beef in Canada is evident from Canadian studies published

in 1990 and 2000 which reported STEC prevalence rates of 33% to 36% to an average prevalence rate of 1.82% in 2012 to 2015. The number of samples tested was not reported in the paper.

On post eviscerated, pre-chill carcasses (*n* = 402) after application of a carcass wash and/or anti-microbial interventions. Essendoubi *et al.* (2019) noted that 5.2% samples were positive for *E. coli* O157:H7and 3.9% positive for non-O157 STEC (serogroups O26, O45, O103, O111, O121 and O145).

Bohaychuk *et al.* (2011) also considered prevalence on beef carcasses with 5.5% of 1,018 samples being found to be positive.

The Foodnet Canada (PHAC, 2018a) data for 2018 indicates a 1.4% prevalence from 362 samples (the testing done would have been for serogroups O157 and O26, O45, O103, O111, O121 and O145).

The CFIA (2019e) report on bacterial pathogens gives data from samples tested from April 1st 2016 to March 31st 2019. This notes the testing of 589 raw ground beef samples with 7 (1.2%) being positive for non-O157 STEC.

12.2. Lamb

12.2.1. Market overview

The Canadian sheep/lamb industry is relatively small compared to that of beef with approximately one million sheep and lamb raised across the country.

The main export destinations for lamb are to the USA and United Arab Emirates (UAE). The US imports most of the edible offal and fresh bone-in sheep cuts whilst UAE import most of the fresh lamb carcasses (Chauvin, 2019).

12.2.2. Production processes

12.2.2.1. Biosecurity

The National Sheep Producer Biosecurity Planning Guide is a tool used by sheep producers in Canada. It was developed by the Canadian Food Inspection Agency (CFIA) and covers how to develop a biosecurity plan, risk assessment and risk management (CFIA, 2013). Livestock is subject to mandatory identification and traceability (DG Santé, 2015).

12.2.2.2. Transport and slaughter

Transport and slaughter rules are the same for beef, pork and lamb in Canada, more information can be found in section 12.1.2.2.

12.2.2.3. Ante and post-mortem inspection

Ante and post-mortem inspection requirements are the same for beef, pork and lamb in Canada, more information can be found in section 12.1.2.3.

12.2.2.4. Chilling and other intervention steps

Chilling and pathogen reduction treatment requirements are the same for beef, pork and lamb in Canada, more information can be found in section 12.1.2.4.

If exporting to the EU, chemicals may not be used, as the EU only allows washing lamb with potable water, clean water, or recycled hot water.

12.2.3. Microbiology

12.2.3.1. Microbiological criteria

Safe Food for Canadians Regulations (SFCR) came into force in January 2019 (see Section 12.1.3.1.1).

There is a section in these regulations on preventive controls for biological hazards in meat products which predominantly covers the testing of beef products for *E. coli* O157. There is no direct mention of lamb products.

As noted in Section 12.1.3.1.1, meat exports to the EU must adhere to all EU legislation (CFIA, 2019d) including the microbiological criteria noted in Commission Regulation (EC) No 2073/2005.

For meat exported to the USA, requirements are noted in Annex T: Testing *E. coli* in slaughter establishments (CFIA, 2019e). The testing frequency for lamb is noted as 1 test per 300 carcasses.

Process verification criteria requirements are given in Table 23.

12.2.3.2. Prevalence

Lamb or sheep meat were not included in the latest Canadian annual report on national microbiological monitoring (CFIA, 2019f).

12.2.3.2.1. *Salmonella*

No information could be found on *Salmonella* prevalence in Canadian lamb.

12.2.3.2.2. *Campylobacter*

Few studies have been done on *Campylobacter* in lamb. A study in Ontario considered faecal testing and found that 87.8 percent of 48 sheep flocks had at least one faecal sample test positive for *Campylobacter*, and 60.1 percent of pooled faecal samples were positive (Scott *et al.*, 2012). No meat data could be found.

12.2.3.2.3. STEC

The CFIA (2019g) report on bacterial pathogens gives data from samples tested from April 1st 2016 to March 31st 2019. This notes the testing of 194 raw ground lamb samples with 38 (19.5%) being positive for STEC (37 with Non-O157 STEC and 1 with an STEC O157).

12.3. Pork

12.3.1. Market overview

In 2019, there were 22 million pigs in Canada which equates to 2.02 million tonnes of production. 1.2 million tonnes was exported whereas 963,000 tonnes was for domestic consumption. Exports look to remain steady for 2020-2021 as African Swine Fever affects other countries (FAS, 2020).

12.3.2. Production processes

There has been a gradual change from small farms to larger more specialised operations. Virtually all commercial hog production in Canada takes place in a controlled environment implying that, at all times of the year, animals are kept in buildings specialized to the farrowing, growing and finishing stages of raising market hogs. Typically, the most common hog production unit is a specialised farrow-to-finish operation of 200 to 250 sows.

Farrow-to-finish reduces significantly productivity losses associated with stress of movement, adaptation to new environments, changing feed regimes and transmission of diseases. Also, producers can monitor the performance of animals through to maturity, thereby observing final results of breeding programs and other management practices.

Canada introduced a sow productivity and management system in 1984 and there is an ongoing programme of swine improvement. The aim is to have high quality breeding stock.

The processing of the pork is undertaken in facilities with state-of-the-art equipment and technology. In recent years, the industry has restructured resulting in fewer more modern and cost-effective plants which have high speed kill and the latest technology (CPI, 2020).

12.3.2.1. Biosecurity

The Canadian Pork Council published a biosecurity manual for pork in 2010, the National Swine Farm-Level Biosecurity Standard. The manual is designed to integrate to disease

monitoring and surveillance activities in the country as well as traceability standards (CPC, 2010).

12.3.2.2. Transport and slaughter

Transport and slaughter rules are the same for beef, pork and lamb in Canada, more information can be found in section 12.1.2.2.

12.3.2.3. Ante and post-mortem inspection

Ante and post-mortem inspection requirements are the same for beef, pork and lamb in Canada, more information can be found in section 12.1.2.3.

12.3.2.4. Chilling and other intervention steps

Chilling and pathogen reduction treatment requirements are the same for beef, pork and lamb in Canada, more information can be found in section 12.1.2.4.

If exporting to the EU, chemicals may not be used, as the EU only allows washing pork with potable water, clean water, or recycled hot water.

12.3.3. Microbiology

12.3.3.1. Microbiological criteria

No specific Canadian criteria can be found specifically covering bacteria and pork products. Section 47 of the Safe Foods for Canadians Regulations does give details of requirements for controlling microbiological hazards in meat products (see 12.1.3.1.1).

As noted in Section 12.1.3.1.1, for meat exports to the EU, Canadian exporters must adhere to all EU legislation including the microbiological criteria noted in Commission Regulation (EC) No 2073/2005 (CFIA, 2019d).

For meat exported to the USA, requirements are noted in Annex T: Testing *E. coli* in slaughter establishments (CFIA, 2019e). This requires carcasses of cattle, pigs, sheep, goats, horses etc. to be tested. The testing frequency for swine is noted as 1 test for 1,000 carcasses.

Process verification criteria are given in Table 23.

Trichinella is covered in Section 157 of the Safe Food for Canadians Regulations which state:

A licence holder may identify as edible a meat product that is derived from a pig and that does not require further preparation before consumption, other than washing or thawing or exposing it to sufficient heat to warm it without cooking it, only if the conditions for identifying the meat product as edible under section 125 are met and

a) the pork is subjected to a treatment or process that inactivates *Trichinella* spp. viable larvae;

b) the pork is derived from a carcass that tests negative for the detection of *Trichinella* spp. larvae using a method that is shown by evidence to be effective; or

c) the pig originates from a farm that operates an on-farm food safety program under which the risk of *Trichinella* spp. infection is negligible.

12.3.3.2. Prevalence

12.3.3.2.1. *Salmonella*

A paper by Bohaychuk *et al.* (2011) considered *Salmonella* prevalence in pork carcasses in Alberta. They tested 1076 samples and found a prevalence of 1.6%.

In 2017, Sanchez-Maldonado *et al.* considered the prevalence of *Salmonella* in two pork processing plant in Alberta. They swabbed carcasses at various points in the abattoir and found relatively high levels of *Salmonella*, however, *Salmonella* was not detected in any retail samples from both plants.

12.3.3.2.2. *Campylobacter*

The 2011 paper by Bohaychuk *et al.* reported on 1,070 samples of pork carcass swabs that had an 8.8% prevalence.

In 2017, Narvaez-Bravo *et al.* considered *Campylobacter* in retail meats in Canada. They tested 147 pork samples and found no *Campylobacter* present.

12.3.3.2.3. STEC

Bohaychuk *et al.* (2011) also tested pork carcass swabs for STEC and found a 4.8% prevalence from 1,067 samples.

12.3.3.2.4. *Trichinella*

In Canada, the CFIA administers a *Trichinella* control program which includes surveillance, regulation and testing. Trichinellosis is a reportable disease under the Health of Animals Act and must be reported to CFIA. As of 30/6/20 only one premises has been affected by Trichinellosis and that was recorded on 23/1/2013.

A paper by Appleyard & Gajadhar (2000) noted that “repeated serological and parasitological analyses of commercially raised swine have shown the Canadian swine herd to be free of *Trichinella* in recent years in all regions of the country except for sporadic cases from one community in Nova Scotia”.

12.4. Poultry

12.4.1. Market overview

Canada imports a large quantity of chicken meat from the USA to be further processed and then re-exported back to the USA. This re-exporting comprises of around 50% of exports, the rest is mostly exporting dark meat to developing countries. Broilers represent nearly all of Canadian chicken meat production at around 98%. Unlike other large producers of poultry meat, farmers are independent of the production companies and are often small establishments. Supply to slaughterhouses is controlled through a quota system run by the Chicken Farmers of Canada (CFC) (FAS, 2019).

12.4.2. Production processes

The Canadian Food Inspection Agency (CFIA) has requirements for each export area on their website, as well as general requirements for Canadian poultry processing facilities. CFIA requires their veterinarians to be present onsite when slaughtering poultry for export to the EU (CFIA, 2018a). The CFIA website also holds guidance for how processing plants should be organised and a Post-mortem Examination Program to provide a standardised approach to the industry (CFIA, 2018b).

12.4.2.1. Biosecurity

There are two mandatory programmes Canadian poultry farmers must comply with. The first is Raised by a Canadian Farmer On-Farm Food Safety Program (CFC, 2021a) and the second is Raised by a Canadian Farmer Animal Care Program developed by Chicken Farmers of Canada (CFC 2018, 2021b). This is a comprehensive national program that regulates, promotes and enforces the production of safe poultry at the farm level and set out the regulations and guidelines for the care and handling of the birds. Compliance is checked annually during audits.

The On-Farm Food Safety Program emphasizes animal health, cleanliness and safety throughout each step of the production cycle and follows strict biosecurity measures to protect animal health and prevent flock infections from outside sources. These mandatory rules govern chicken farms from throughout Canada and include

requirements for biosecurity, disease prevention, feed and water management and testing, along with the associated recordkeeping to demonstrate compliance. The program has been recognised by the Canadian Food Inspection Agency (CFIA).

12.4.2.2. Transport and slaughter

Transport and slaughter rules for poultry are the same as for beef, pork and lamb in Canada; more information can be found in section 12.1.2.2.

12.4.2.3. Ante and post-mortem inspection

Ante-mortem and post-mortem inspections are undertaken by CFIA veterinary inspectors. On application for a licence, CFIA will determine how many inspection stations will be needed and where. On certain conditions, the licence holder may be permitted to conduct post-mortem examination instead of post-mortem inspection conducted by an inspector (CFIA, 2018b).

Ante-mortem examination of a food animal (for larger animals) or a sample from the shipment of food animals (for birds) is done within 24 hours before slaughter by a licence holder. To verify the results of the ante-mortem examination, ante-mortem inspection by a veterinary inspector or an inspector under the supervision of a veterinary inspector must also take place within 24 hours before slaughter (CFIA, 2019b).

Post-mortem examination is done by a licence holder under the supervisions of a veterinary inspector, if an authorisation to conduct a Post-Mortem Examination Program has been granted. Otherwise, it is inspected by an inspector (CFIA, 2019b).

12.4.2.4. Chilling and other intervention steps

Similar to the US, Canada has a graded system for time taken to reach specific temperatures during water immersion chilling based on the bird's weight (see Table 26).

Table 26: Canada, Poultry – Chilling time according to carcass weight

Weight of dressed poultry carcasses (kg)	Initial time to reach ≤ 14°C (hrs)	Additional time to reach ≤ 6°C (hrs)	Additional time to reach ≤ 4°C (hrs)
≤ 1.80	2	2	4

1.81 ≤ 3.60	2	4	4
3.61 ≤ 5.00	2	6	4
5.01 ≤ 7.00	2	8	4
7.01 ≤ 12.00	2	10	4
> 12.01 kg	2	10	6

Source: CFIA, 2019d

There is also a general statement which specifies parts of carcasses should be below 4°C within 2 hours. For air chilling there is no time specified, but the requirements to achieve 4°C remains the same. The carcasses should be continuously chilled, and the air temperature should remain below 4°C (CFIA, 2019h).

If exporting to the EU, chemicals may not be used, as the EU only allows washing poultry with potable water or clean water.

12.4.3. Microbiology

12.4.3.1. Microbiological criteria

Safe Food for Canadians Regulations (SFCR) came into force on 15 January 2019. Within the SFCR there is a requirement to identify and analyse the biological, chemical and physical hazards that present a risk of contamination of a food. For poultry, this means implementing a specific Poultry Pathogen Reduction Program (CFIA, 2018d). The main objectives of the Poultry Pathogen Reduction Program in slaughter establishments are noted to be:

- to reduce and/or eliminate food safety pathogens using a Preventative Control Plan (PCP)
- to measure effectiveness of controls applied during evisceration process by:
    - using food safety indicator pathogens; and
    - using a validated standard

A validated pathogen reduction standard is noted for following pathogens:

- *Salmonella* spp.

- *Campylobacter* spp.
- generic *Escherichia coli* (*E. coli*) – Biotype I (Note: This is not considered a pathogen but a hygiene indicator organism)

Relevant USDA Performance Standards can be used to meet this requirement (CFIA, 2018d). The USDA Performance Standards for *Salmonella* and *Campylobacter* can be found in annexes U and U-1 of the Special Requirements for Export Markets website of the CFIA (2017; 2019i).

12.4.3.1.1. *Salmonella*

Table 27: Canada, Poultry – USDA Performance Standards for *Salmonella* by class of product

Class of Product	Number of Samples to be tested per set ("n")	Maximum Number of Positives per set ("c")
Young chickens	51	5
Ground chicken	53	26
Young turkey carcasses	56	4
Ground turkey	53	29

Sources: 9 CFR 310.25 (7), Jan. 1st 2012 and FSIS Notice 54-12 (09/11/ 2012)

The requirement in Canada appears to be for testing to be done daily, each test in a set being done on consecutive days until “n” is achieved. Testing must be done in ISO 17025 accredited laboratories using defined methods. Samples are taken using a whole bird rinse (chicken) or a sponge (turkey). If the number of positive tests is equal or less than “c” then no further testing is required for that year. If the number of positives is >”c” then a review is required with corrective actions noted and a second or third set of testing is required.

12.4.3.1.2. *Campylobacter*

Table 28: Canada, Poultry – USDA Performance Standards for *Campylobacter* in chilled carcasses of young chickens and turkeys

Class of Product	Number of samples to be tested per set (“n”)	Maximum number of positives per set (“c”)

Young chickens	51	8
Young turkeys	56	3

Source: FSIS Notice Number 54-12 (09/11/2012)

The *Campylobacter* test is a presence or absence test (not enumeration) and like the testing for *Salmonella* is undertaken in ISO 17025 laboratories using defined methods.

There are specific requirements for meat exported to the EU. These refer to the Commission Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs and also include the variation with respect to Finland and Sweden noted in Commission Regulation 1688/2005 (special guarantees concerning *Salmonella* for consignments to Finland and Sweden of certain meat and eggs).

Commission Regulation (EC) No 2073/2005 details the sampling rules for poultry carcasses and fresh poultry meat; provides guidelines for sampling and sampling frequencies for carcasses, minced meat, meat preparations, mechanically separated meat and fresh poultry meat. Further details of EU microbiological criteria are available in Annex 1.

12.4.3.2. Prevalence

Canada conducted a National baseline study in broiler chicken from December 2012 to December 2013 (CFIA, 2016b). This generated the information in Table 29 to Table 33.

12.4.3.2.1. *Salmonella*

Table 29: Canada, Poultry – Prevalence of Salmonella in broiler chicken lots by province / region

Province	Lots	*Salmonella* positives	Positives (%)
British Columbia	743	143	19.2
Alberta	584	104	17.8
Midwest	596	104	17.4
Ontario	1,032	354	34.3
Quebec	997	288	28.9
Maritimes	395	118	29.6

Canada (Total)	4,347	1,111	25.6

Table 30: Canada, Poultry – Prevalence of *Salmonella* on fresh retail chicken

Sample type	Sample numbers	*Salmonella* positives	Positives (%)
Whole carcass	404	85	21.0
SLBL breasts	834	262	31.4
SOBI thighs	405	130	32.1
Parts	1,239	392	31.6
All products	1,646	477	29.0

Note: SLBL= Skinless and boneless; SOBI= Skin on and Bone in

12.4.3.2.2. *Campylobacter*

Table 31: Canada, Poultry – Prevalence of *Campylobacter* in broiler chicken lots by province/region

Province	Lots	*Campylobacter* positives	Positives (%)
British Columbia	726	300	41.3
Alberta	573	145	25.3
Midwest	579	131	22.6
Ontario	1,012	203	20.1
Quebec	973	153	15.7
Maritimes	390	93	23.8
Canada (Total)	4,253	1,025	24.1

Table 32: Canada, Poultry – Prevalence of *Campylobacter* on fresh retail chicken

Sample type	Agar plate method Number tested	Agar plate method *Campylobacter* positives (%)	Enrichment method. Number tested	Enrichment method *Campylobacter* positives (%)	Combined number of tests	Combined *Campylobacter* positives (%)

Whole carcass	404	22.0	402	34.3	404	37.9
SLBL breasts	841	17.6	793	40.7	841	43.3
SOBI thighs	406	27.3	382	34.6	406	42.6
Parts	1,247	20.8	1,175	38.7	1,247	43.1
All products	1,654	21.1	1,579	37.6	1,654	41.8

Note: SLBL= Skinless and boneless; SOBI= Skin on and Bone in

Table 33: Canada, Poultry – Distribution of *Campylobacter* concentrations on fresh retail chicken

Range of *Campylobacter* counts (cfu/ml)	Number of samples	Percent of total
<1	1,303	78.9%
1 – 10	231	14.0%
10.07 - 100	84	5.1%
100.01 – 1,000	16	1.0%

More recently, Narvaez-Bravo *et al.* (2017) considered *Campylobacter* in retail meats in Canada. They tested 204 retail chicken samples and found 48 positives (23.5% prevalence).

12.5. Antimicrobial resistance

In Canada, as of December 1, 2018, all Medically Important Antimicrobials (MIAs) for veterinary use were only sold by prescription. Additionally, all growth promotion claims were removed from these antibiotics.

In 2017, Public Health Agency of Canada (PHAC, 2017a) published a document on tackling antimicrobial resistance and antimicrobial use which set out a framework of surveillance, infection prevention, stewardship, and research and innovation. PHAC also runs the Canadian Antimicrobial Resistance Surveillance System (CARSS) which is the Canadian national system for reporting AMR and antimicrobial use (PHAC, 2018b). Data is generated via the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) (PHAC, 2007) as it collects, analyses and communicates trends in antimicrobial use and antimicrobial resistance from humans, and food animals.

Chicken Farmers of Canada (CFC) have their own antimicrobial use strategy (CFC, 2021b). Preventive uses of Category I antibiotics eliminated throughout the chicken sector since 2014. Preventive uses of Category II antibiotics were discontinued at the end of 2018. The goal was to eliminate the preventive uses of Category III antibiotics by the end of 2020. There is a good surveillance program in place and an active procedure for reducing antimicrobial use in poultry production. Details of the effects of this are varied, with AMR in some organisms decreasing whist there are increases in some type of resistance in some others. A review of this area is given in Agunos *et al.* (2019).

In CARSS 2017 update (PHAC, 2017b), a comparison was made between European (ESVAC) data for 31 European countries from 2015 and the Canadian data from 2016. This comparison would have placed Canada as the fifth highest for consumption of antimicrobials measured as milligram of drug per kilogram of animal (equivalent to mg/PCU). Overall, although the use decreased from 170 mg/PCU in 2006 to 150 mg/PCU (or 987,157 kg sold) in 2016, at that time Canada had a higher antibiotic consumption than the reported average of 135.5 mg/PCU for the European countries (ESVAC countries).

In CARSS 2018 update (PHAC, 2018b) on antimicrobial use in food producing animals and companion animals, PHAC noted that, in 2017, the total volume of these antimicrobials (excluding ionophores and chemical coccidiostats) was approximately

950,000 kilograms, or nearly four times the amount used in humans. The quantity of antimicrobials intended for use in animals was 11% lower than in 2016 and represented the lowest volume of sales since reporting began in 2006. Almost all of the antimicrobials were distributed for use in food-producing animals. Overall, there was a significant increase in the number of sentinel farms reporting that medically important antimicrobials were not used. In 2017, 32% of pig farms and 19% of chicken farms reported no use of these products, compared to 11% and 7% in 2016, respectively. There was no reported use of fluoroquinolones or third-generation cephalosporins by sentinel chicken farms, consistent with recent Canadian policy changes that introduced a ban on the preventative use of Category I antimicrobials on poultry farms across Canada. On the other hand, this would mean that amounts used on farms using these antimicrobials can be substantially higher than the national average.

The CARSS update in 2020 (PHAC, 2020) noted that between 2014 and 2018 the use of antimicrobials (as kg used) for animals decreased by 11% (from 1.13 to 1.00 million kg); however, there was a 6% increase between 2017 and 2018. The recent increase was primarily driven by an increase in the quantity of tetracyclines, but there was also an increase in the distribution of fluoroquinolones – from 640 kg in 2017 to 677 kg in 2018. The update also compared Canadian data from 2018 to European (ESVAC) data from 2017 and placed Canada in sixth position out of all 31 of the European countries noted in ESVAC in terms of mg/PCU based on European weight of animals (the exact number for Canada was not indicated in the report but it appears to be below 150 mg/PCU).

This update also goes into some detail about the AMR resistance patterns from enteric bacteria recovered from various meat retail samples from 2014 to 2018. The following is reported in relation to beef, pork, and poultry.

Table 34: Canada, Beef – Antimicrobial resistance patterns in *Escherichia coli* isolates recovered from retail beef meat samples, Canada, 2014-2018. Proportion of	**2014**	**2015**	**2016**	**2017**	**2018**

resistant isolates per year. Antimicrobial					
(*n*) positive (% recovery)	464 (50%)	280 (43%)	257 (49%)	218 (43%)	122 (39%)
Ampicillin	5.4	4.9	4.3	6.9	5.7
Ceftriaxone	0.7	0.4	0.8	0.0	0.0
Chloramphenicol	4.6	2.3	2.7	5.1	4.1
Ciprofloxacin	0.0	0.0	0.0	0.5	0.0
Gentamicin	0.7	0.4	0.4	0.9	0.8
Nalidixic acid	1.3	1.9	0.8	1.4	2.5
Streptomycin	9.6	11.0	7.4	9.6	9.0
Tetracycline	17.0	21.2	12.5	17.4	16.4
Trimethoprim-sulfamethoxazole	3.5	2.7	1.6	1.8	4.9

Table 35: Canada, Pork – Antimicrobial resistance patterns in *Escherichia coli* isolates recovered from retail pork meat samples, Canada, 2014-2018. Proportion of resistant isolates per year.

Antimicrobial	2014	2015	2016	2017	2018
(*n*) positive (% recovery)	339 (30%)	191 (24%)	140 (21%)	115 (18%)	51 (13%)
Ampicillin	24.8	26.3	20.7	20.0	19.6
Ceftriaxone	4.6	1.7	2.9	1.7	2.0
Chloramphenicol	7.1	7.8	7.9	5.2	2.0
Ciprofloxacin	0.0	0.0	0.0	0.0	0.2
Gentamicin	1.9	0.0	1.4	0.9	3.9
Nalidixic acid	0.9	0.0	0.0	0.9	3.9
Streptomycin	27.9	36.3	24.3	24.3	21.6
Tetracycline	44.9	51.4	37.9	38.3	29.4
Trimethoprim-sulfamethoxazole	9.0	10.6	10.0	6.1	7.8

Table 36: Canada, Poultry – Antimicrobial resistance patterns in *Escherichia coli* isolates recovered from retail chicken meat samples, Canada, 2014-2018. Proportion of resistant isolates per year.

Antimicrobial	2014	2015	2016	2017	2018
(*n*) positive (% recovery)	626 (92%)	402 (93%)	311 (93%)	293 (90%)	180 (88%)
Ampicillin	42.0	41.6	39.9	39.9	37.2
Ceftriaxone	19.6	16.7	9.3	6.5	6.7
Chloramphenicol	6.1	6.0	4.2	4.4	6.1
Ciprofloxacin	0.0	0.0	1.0	0.3	0.0
Gentamicin	19.2	20.3	33.1	25.9	31.1
Nalidixic acid	2.9	3.0	4.8	4.1	4.4
Streptomycin	42.3	48.2	53.4	50.5	60.0
Tetracycline	49.8	52.9	52.4	50.2	48.3
Trimethoprim-sulfamethoxazole	13.6	15.3	17.0	13.3	23.3

Table 37: Canada, Poultry – Antimicrobial resistance patterns in *Campylobacter* spp. isolates recovered from retail chicken meat samples, Canada, 2014-2018. Proportion of resistant isolates per year.

Antimicrobial	2014	2015	2016	2017	2018
(*n*) positive (% recovery)	294 (26%)	203 (25%)	176 (27%)	165 (25%)	103 (25%)
Azithromycin	4.7	5.0	1.7	4.2	13.6
Ciprofloxacin	10.8	16.1	19.3	18.8	13.6
Gentamicin	0.0	0.0	0.0	0.0	0.0
Tetracycline	46.2	44.2	45.5	39.4	25.2

Table 38: Canada, Poultry – Antimicrobial resistance patterns in *Salmonella* spp. isolates recovered from retail chicken meat samples, Canada, 2014-2018. Proportion of resistant isolates per year.

Antimicrobial	2014	2015	2016	2017	2018
(*n*) positive (% recovery)	348 (30%)	297 (37%)	183 (28%)	167 (26%)	130 (32%)
Ampicillin	21.3	14.2	7.1	8.4	9.4
Ceftriaxone	21.0	12.8	6.6	6.0	9.4
Chloramphenicol	0.6	0.3	0.6	0.0	0.8
Ciprofloxacin	0.0	0.0	0.0	0.0	0.0
Gentamicin	2.6	1.1	3.3	4.2	3.1
Nalidixic acid	0.3	1.4	0.0	1.2	0.8
Streptomycin	19.0	31.7	36.1	37.1	44.1
Tetracycline	18.7	33.5	33.9	31.7	40.2
Trimethoprim-sulfamethoxazole	0.0	1.1	1.1	1.2	2.4

With respect to lamb, data cannot be found within CARSS update reports. Scott *et al.* (2012a; 2012b) have noted that little is known about antibiotic use or AMR in sheep in Canada (it is noted that they are a minor livestock group). These authors studied sheep flocks in Ontario and noted that resistance was infrequent among *Salmonella* (0%, *n* = 7 isolates) and low among *E. coli* (13.1%; *n* = 849) isolates. A small number of isolates were resistant to antimicrobials classified as being of very high importance to human health.

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13. USA

13.1. Beef

13.1.1. Market overview

The meat and poultry sector is the largest segment of US agriculture. Different livestock however feature more predominantly in some states than others. Cattle farming is mainly carried out in the states of Nebraska, Kansas, Texas, Colorado, California, Wisconsin, Washington and Pennsylvania (NAMI, 2017).

The trend has been to fewer and more extensive enterprises in both the beef and pork sectors.

Originally beef cattle were moved around to wherever the grass was. Currently, the US is reported to be the world's largest producer of beef. Beef cattle are mostly grain fed (calves and beef cows forage on range and grassland and have little grain feeding). Beef is used both domestically and for export. The US is also an importer of grass-fed beef which is described as being of lower value and used in processing (ERS, 2019a). The size of the US cattle herd has generally been declining since the mid-1970s with a recent low in 2014. Since then it has been increasing again and was reported to be 94.4 million head on January 1, 2020 (ERS, 2020a).

The main markets for export are Japan (26%), South Korea (23%), Mexico (14%), Canada (9%), and Hong Kong (8%) (ERS, 2020a).

As of May 2020, there are around 500 beef slaughter and cutting plants in the US. A live database "Meat, Poultry and Egg Product Inspection Directory" can be used to search by sector and a full list of registered premises can be found (FSIS, 2020a).

13.1.2. Production processes

The US beef industry is largely separate from the dairy sector (which differs from many other countries). The beef livestock production process is lengthy, taking 2-3 years, and is split into two sectors: cow-calf operations and cattle feeding (ERS, 2020a).

Meat processing is overseen by the Food Safety and Inspection Service (FSIS). Inspection is carried out on all plants processing meat for interstate or export sale. The Federal Meat Inspection Act provides all necessary requirements for safe inspection of carcasses as well as tying in with the Humane Methods of Slaughter Act.

13.1.2.1. Biosecurity

The US Environmental Protection Agency (EPA) have standard operating procedures for visiting livestock and poultry facilities. These include guidance on personal protective equipment, visiting facilities and decontamination procedures. The guidance grades activities by risk level, and with each increase of risk more measures are put in place. Level 1 accounts for visits to farms where there is no contact with the animals, these still include techniques such as boot washing. Level 2 is designed for farm visits where there is minimal contact with livestock, level 3 is for close contact. (EPA, 2016). These measures are similar to the guidance published in the UK and the EU.

13.1.2.2. Transport and slaughter

Slaughter of animals cannot take place unless an FSIS inspector is present. To be granted FSIS inspection onsite establishments must prove they have an adequate HACCP plan and sanitation procedure in place, they have completed a hazard analysis and that they comply with all FSIS requirements. The FSIS inspector is required to verify these and if found not to be compliant has the authority to take regulatory action to stop processing (FSIS, 2013a).

13.1.2.3. Ante and post-mortem inspection

Ante-mortem inspection must be overseen by an FSIS employed inspector. Inspectors will monitor live animals both stationary and in motion to look for physical condition and any signs of disease. When not performing these inspections FSIS staff will move throughout the establishment to other parts of the process. After slaughter and bleeding, inspectors will examine carcasses for any signs of disease or pathological conditions that would render it unsuitable for human consumption. Any carcasses taken away from production are further inspected by a veterinarian for a final decision. Establishments must retain the identity of every carcass and ensure it does not reach the food chain unless a veterinarian approves its release (FSIS, 2013a).

13.1.2.4. Chilling and other intervention steps

Unlike other nations, the USA has no specific time or temperature requirements for chilling meat carcasses, just rules for poultry (see sections 5.3 and 13.4.2.4). Instead, individual plants use their own HACCP plans to control the temperature in order to reduce pathogen levels on the surface of the meat. Some plants use a metric of less than 4°C just beneath the surface of the meat within the first 24 hours (Savell, 2012). This is quite different from EU rules where carcasses must be brought down to less than 7°C as soon as possible in the centre of the carcass/cut.

Spray chilling is a technique which has been used routinely in US beef production for many years. This is where carcasses are intermittently sprayed with cold water during the first stages of cooling and is used to reduce shrinkage from evaporative loss in air chillers. This practice is stopped at a certain stage throughout the initial chill as the surface needs to dry off in order to be graded for quality. Studies have shown that the proliferation of growth on the surface of non-sprayed or spray chilled with no chemicals are very similar but using chemical agents within the spray water reduces the microbial count (Greer & Jones, 1997; Gill & Landers, 2003; Stopforth *et al.*, 2004).

13.1.3. Microbiology

13.1.3.1. Microbiological criteria

13.1.3.1.1. *Salmonella*

The USDA Food Safety and Inspection Service (FSIS) plays a regulatory role in preventing the contamination of meat, poultry and processed egg products with foodborne pathogens (AMA, 2015). FSIS implemented mandatory performance testing for *Salmonella* in certain meat products with the 1996 Pathogen Reduction/HACCP Systems Final Rule (FSIS, 1996). This Final Rule required that establishments that slaughtered or prepared certain ground meats meet *Salmonella* performance standards based on nationwide baseline rates of *Salmonella* contamination in that type of meat. The implementation of performance standards by FSIS has resulted in the adoption of various internal testing programs by many meat and poultry producers (FSIS, 2013b).

On 28 October 2019, FSIS published a notice in the Federal Register detailing proposed changes to the *Salmonella* performance standards for raw ground beef and beef manufacturing trimmings (FSIS, 2019a). The proposed new approach is:

- implement a 52-week “moving window” of testing
- collect and analyse at least 48 samples per year for each establishment producing greater than 50,000 pounds of ground beef or beef manufacturing trimmings per day
- the maximum allowable number of *Salmonella* positives from the 48 samples would be 2 (4.1% positive).

Table 39: USA, Beef – Updated or new Performance Standards for *Salmonella* in raw ground beef and beef manufacturing trimmings

Product (establishment volume in lbs./day)	Maximum number of allowable positive samples	Minimum number of samples needed to assess establishment performance *
Raw ground beef (>50,000)	2 of 48	48
Beef manufacturing trimmings (>50,000)	2 of 48	48

Source: (FSIS, 2019a)

* Any establishment with three or more *Salmonella* positives in a 52-week window would be categorized as *not meeting* the performance standard even when less than the minimum number of samples (48) are collected/analysed.
Full details of sampling methods are given by USDA.

13.1.3.1.2. *Campylobacter*

The literature review found no evidence of performance standards for *Campylobacter* in beef in the USA.

13.1.3.1.3. STEC

It is required to test beef trimmings for a group of STEC serogroups. These are generally known as the USDA big six and are O157 and 6 others (O26, O45, O103, O111, O121, and O145). The method used is known as the N60 method, which is a composite testing method in which 60 samples are taken from the outer surfaces of a meat block giving a

total sample weight of 375g. This single composite sample is tested for STEC O157 and the Big 6 (FSIS, 2014a). Samples positive in the test cannot be sold and must be disposed of or treated to eliminate the organisms.

13.1.3.2. Prevalence

13.1.3.2.1. *Salmonella*

A summary of prevalence information is given in Table 40.

Table 40: USA, Beef – Summary of *Salmonella* prevalence data

Sample type	Year	Reported prevalence	Reference
Ground beef	2005-2007	4.2% (*n* = 1,436)	Bosilevac *et al.*, 2009
Ground beef	2002-2005	1% (*n* = 3,904)	Zhao *et al.*, 2006
Beef steaks	2001	1.9% (*n* = 210)	Zhao *et al.*, 2001
Beef (retail)	2007	0% (n = 133 samples)	Kegode *et al.*, 2008

13.1.3.2.2. *Campylobacter*

Table 41: USA, Beef – Summary of *Campylobacter* prevalence data

Sample type	Year	Reported prevalence	Reference
Beef steaks	2001	0.5% (*n* = 182)	Zhao *et al.*, 2001
Beef (retail)	2007	0% (*n* = 133)	Kegode *et al.*, 2008

A study of the prevalence of *Campylobacter* in faeces found that 19.2% (*n* = 944) of samples were positive (Sanad *et al.*, 2011). A further study of cattle in feedlots reported that 72.2% (*n* = 3,184) of animals were positive for either *C. jejuni* or *C. coli* (Tang *et al.*, 2017). The difference between prevalence in cattle pre-slaughter and the post-slaughter product implies that controls to prevent contamination of beef products are effective.

13.1.3.2.3. STEC

Data from USDA Quarterly Summary Tables 01/01/2020 to 31/03/2020 (FSIS, 2020b).

Table 42: USA, Beef – USDA quarterly summary table of STEC prevalence

Beef type	No. samples	No. positive O157	% positive O157
Raw ground beef (retail)	117	0	0
Raw ground beef	2,647	1	0.04
Beef manufacturing trim	1,037	2	0.19
Raw ground beef components other than trim	310	0	0
Bench trim	347	0	0
Total for raw beef	4,458	3	0.07

In 2013, Magwedere *et al.*, reported on the incidence of STEC in beef in Pennsylvania and Virginia. They tested 51 samples and found 18 positives (35% prevalence made up of: 11 x O121, 6 x O45, and 1 x O145). However, they report that none contained *stx* genes and were not considered STEC.

13.2. Lamb

13.2.1. Market overview

Lamb and mutton production have decreased in recent years but conversely the number of operations has increased (83,000 in 2007 to upward of 101,000 in 2017). It is considered this may be due to the ability to count smaller operations. More than two-thirds of U.S. operations are located in the Southern Plains, Mountain, and Pacific regions, and the regional distribution has remained fairly constant since the early 1900s. Texas is the largest sheep producing State, followed by California.

Sheep-producing operations range in size from those with small flocks to large western operations. Two types of enterprises exist: stock-sheep production and lamb feeding. Stock-sheep producers manage grazing flocks on pasture and range forage, often on arid western lands with few alternative uses. Stock-sheep producers sell lambs that are either slaughtered or placed in feedlots. Feeder lambs are raised on forage until they are around 60-80 pounds, and then placed in feedlots to be fattened and finished for slaughter.

US lamb consumers prefer high-quality cuts such as legs and loins. Some of the lower quality, less desirable cuts go to the pet-food industry or are exported (ERS, 2020b).

13.2.2. Production processes

Lambs are nursed by their mothers and when they are weaned, they gradually begin feeding on pasture or coarsely ground grain. They are fed hay and feed consisting of corn, barley, milo (a type of sorghum), and/or wheat supplemented with vitamins and minerals. Lambs are usually “finished” (grown to maturity) in feedlots where they are fed specially formulated feed. While most lambs are finished on grains, some lambs are raised on pasture and are finished on grass instead of grains. Grass-finished lamb is usually distinguished on the label (FSIS, 2013c).

Lamb is produced from younger animals, typically less than a year old, and mutton is produced from older animals. Most lambs are brought to market at about 6 to 8 months old. A lamb weighs about 140 pounds and yields approximately 46 to 49 pounds of edible

lean retail lamb cuts, semi-boneless. If the phrase “Spring Lamb” is on a meat label, it means the lamb was slaughtered between March and October.

13.2.2.1. Biosecurity

Biosecurity standards are the same for all livestock, further details can be found in section 13.1.2.1.

13.2.2.2. Transport and slaughter

Transport and slaughter requirements are the same for all livestock and can be found in section 13.1.2.2.

13.2.2.3. Ante and post-mortem inspection (as US beef)

Ante and post-mortem requirements are the same for all livestock and can be found in section 13.1.2.3.

13.2.2.4. Chilling and other intervention steps

The USA has no specific time or temperature requirements for chilling meat carcasses, see section 13.2.1.4 for more details.

Additives are not allowed on fresh lamb. Hormones and antibiotics approved by the U.S. Food and Drug Administration (FDA) are permitted to be used in lambs slaughtered for meat. Antibiotics may be given to prevent or treat disease in lambs and hormones may be given to promote efficient growth. A recommended withholding period is required from the time antibiotics are administered until it is legal to slaughter the animal. This is so drug residues can exit the animal's system. FSIS samples lamb carcasses at slaughter and tests for residues. FSIS laboratory results above the tolerance limit set by FDA is considered a residue violation and are investigated by FDA or the State (FSIS, 2013a).

13.2.3. Microbiology

13.2.3.1. Microbiological criteria

No microbiological criteria specifically for lamb in the USA was found. Sometimes lamb appears to be collected into a category of “meat”.

13.2.3.2. Prevalence

13.2.3.2.1. *Salmonella*

A study (in U.S. sheep Kalchayanand *et al.*, 2007, quoted in APHIS, 2013) tested 2,592 sponge samples from pelt, pre-evisceration, and post-intervention carcasses from multiple large commercial lamb processing plants in the USA. The authors found that 14.4 percent of lamb pelts (*n* = 851), 4.3 percent of pre-evisceration carcasses (*n* = 851), and 1.8 percent of post-intervention carcasses (*n* = 851) at a US slaughterhouse tested positive for *Salmonella*.

13.2.3.2.2. *Campylobacter*

APHIS (2014) reports on testing 2,367 animal faecal samples for *Campylobacter* of which 465 (19.6%) tested positive.

Whilst data on *Campylobacter* prevalence is not routinely collected, the data available suggests that contamination rates of post-slaughter lamb products is low. A study published in 2001 (Duffy *et al.*, 2001) found a prevalence rate of 0.3% (*n* = 2,226) in chilled lamb carcasses.

13.2.3.2.3. STEC

Kalchayanand *et al.* (2007) reported on testing a total of 2,592 sponge samples from pelt, pre-evisceration, and postintervention carcasses from multiple large commercial lamb processing plants. A total of 488 non-O157 STEC strains were isolated from postintervention carcasses. The prevalence of non-O157 STEC from pelts, pre-evisceration carcasses, and postintervention carcasses averaged 86.2, 78.6, and 81.6%, respectively. Sixty-nine different serotypes of non-O157 STEC were identified. The most frequently detected serotypes were O91:H14 (40.8%) followed by O5:H19 (18.4%). A small number of STEC serotypes associated with severe human illness were isolated from postintervention carcasses. Of 488 isolates, these were serotypes O76:H19, O128:H2 (0.8%), O146:H8 (2.1%), O146:H21, O163:H19, and O174:H8 (1.3%).

These authors noted the prevalence of *E. coli* O157:H7 from pelt, pre-evisceration, and postintervention carcasses averaged 12.8%, 1.6%, and 2.9%, respectively.

13.3. Pork

13.3.1. Market overview

Since 1995, the USA has been a net exporter of pork supplying fresh-chilled (higher price cuts for retail sale e.g. loins) and frozen (e.g. boneless bellies and shoulders for processing) pork cuts. In 2016, the USA held 1.9 million tonnes (27%) of the 7 million tonnes of pork exports in the world. Their main export markets include Mexico (which accounts for about one-third of U.S. exports), Japan, China/Hong Kong, and Canada (ERS, 2019b; ERS, 2020c). Most pork processing is carried out in the states of Iowa, Minnesota, Illinois, Indiana, Missouri, Oklahoma and Pennsylvania (NAMI, 2017).

13.3.2. Production processes

Pork is generally produced from young animals (6 to 7 months old) that weigh from 175 to 240 pounds. Much of a hog is cured and made into ham, bacon and sausage. Uncured meat is called "fresh pork" (FSIS, 2013d).

Pig production occurs in 3 stages:

- Farrow-to-finish operations raise hogs from birth to slaughter weight, about 240-270 pounds.
- Feeder pig producers raise pigs from birth to about 10-60 pounds, then generally sell them for finishing.
- Feeder pig finishers buy feeder pigs and grow them to slaughter weight.

There is some overlap in enterprise type. Most use confinement production is specialized environmentally controlled conditions and enable production to continue throughout the year. More recently large operations that specialise in a single phase of production have replaced farrow-to-finish operations that performed all phases of production. Since 1990, the number of farms with hogs has declined by over 70%, as individual enterprises have grown larger. This has been accompanied by technological advancements and evolving economic relationships (e.g. production contracts and vertical integration) among producers, packers, and consumers (ERS, 2019b).

13.3.2.1. Biosecurity

Biosecurity standards are the same for all livestock, further details can be found in section 13.1.2.1.

13.3.2.2. Transport and slaughter

Transport and slaughter requirements are the same for all livestock and can be found in section 13.1.2.2.

13.3.2.3. Ante and post-mortem inspection

Ante and post-mortem requirements are the same for all livestock and can be found in section 13.1.2.3.

13.3.2.4. Chilling and other intervention steps

Unlike other nations, the USA has no specific time or temperature requirements for chilling meat carcasses, just rules for poultry (see sections 5.3 and 13.4.2.4). Instead, individual plants use their own HACCP plans to control the temperature in order to reduce pathogen levels on the surface of the meat. This is quite different from EU rules where carcasses must be brought down to less than 7°C as soon as possible in the centre of the carcass/cut.

Antibiotics may be given to prevent or treat disease in hogs. A "withdrawal" period is required from the time antibiotics are administered until it is legal to slaughter the animal. FSIS randomly samples pork at slaughter and tests for residues. Data from this monitoring program are reported to have shown a very low percentage of residue violations. No hormones are permitted to be used in the raising of hogs (FDA , 2017).

13.3.3. Microbiology

13.3.3.1. Microbiological criteria

FSIS has been running a raw pork products sampling program for a number of years. This began in May 2015 with The Raw Pork Products Exploratory Sampling Program (RPPESP) and was replaced in November 2019 with the Raw Pork Products Sampling

Program. The new program will test for indicator microorganisms and *Salmonella* but not for STEC. Individual sample results will not result in regulatory control actions. Therefore, establishments are not required to hold the sampled production lot pending the *Salmonella* sample results. However, repetitive positive sample results over time may indicate a concern with respect to process control and HACCP system support (FSIS, 2019b).

Criteria are noted in USDA-FSIS 9 CFR Parts 301, 309, and 310 [Docket No. FSIS–2016–0017] RIN 0583–AD62 Modernization of Swine Slaughter Inspection. Under this final rule, establishments, except for very low-volume establishments, are required to collect carcass samples and test for microbial organisms pre-evisceration and post-chill, or, for hot-boned products, pre-evisceration and after the final wash, at a frequency of once per 1,000 carcasses. Very low-volume establishments are required to collect at least one carcass sample during each week of operation starting June 1 of each year. If, after consecutively collecting and testing 13 weekly carcass samples, very low- volume establishments can demonstrate that they are not exceeding their upper control limit for microbial organisms and that they are effectively maintaining process control, they can modify their sampling plans to collect samples less frequently. FSIS provides more information on upper control limits in its guideline titled Developing Effective Microbiological Sampling Programs in Swine Slaughter Establishments (2009) to Assess Process Control and Sanitary Conditions. The sampling guideline is available on FSIS website (FSIS, 2019c).

The Guideline states that an establishment’s measurable science-based standards or parameters may include:

- Sanitary dressing monitoring;
- Zero tolerance for visible contamination checks;
- Microbiological testing results, for indicator organisms (e.g., Aerobic Plate Counts (APC), *Enterobacteriaceae* (EB), generic *E. coli*, total coliforms) and pathogens (e.g., *Salmonella*); and
- Critical operational parameters for antimicrobial interventions (e.g., concentration, pH, temperature).

The microbiological criteria noted for *E. coli* are given in the Table 43.

Table 43: USA, Pork – Performance criteria for generic *E. coli* for swine carcasses using excisional sampling

Lower limit of marginal range (*m*)	Upper limit of marginal range (*M*)	Number of samples tested	Maximum number permitted in the marginal range
10 cfu/cm^2	10,000 cfu/cm^2	13	3

Similarly for “indicator organisms”, see Table 44.

Table 44: USA, Pork – Indicator organism optional upper control limits for market hog carcasses

Factor	APCs: Pre-evisceration	APCs: Post Chill	*Enterobacteriaceae:* Pre-evisceration	*Enterobacteriaceae:* Post Chill	Total coliforms: Pre-evisceration	Total coliforms: Post Chill	*E. coli:* Pre-evisceration	*E.coli:* Post Chill
Average cfu/cm^2	4,200,000	790	8,300	110	5,500	15	1,800	30
Distribution percentile	80%	80%	80%	80%	80%	80%	80%	80%

These procedures and parameters should be incorporated into the establishment’s HACCP plan, sanitation standard operating procedures (sanitation SOPs), or other prerequisite programs (collectively referred to as the establishment’s HACCP system).

With respect to *Trichinella* (FSIS, 2018a), on 5/31/18, FSIS published the final rule “Elimination of Trichinae Control Regulations and Consolidation of Thermally Processed, Commercially Sterile Regulations” (83 FR 25302), which amends the Federal meat inspection regulations to eliminate the requirements that RTE and NRTE pork products be treated to destroy Trichina (*Trichinella spiralis*).

FSIS removed these prescriptive regulations because they were inconsistent with the Hazard Analysis and Critical Control Point (HACCP) regulations and were no longer considered necessary. Establishments now have the flexibility provided by the HACCP regulations (9 CFR Part 417) to develop appropriate science-based controls for *Trichinella* and other parasitic hazards in pork. All establishments producing pork products will have to determine whether *Trichinella* is a hazard reasonably likely to occur in their processes. If so, they will need to address this hazard in their HACCP system.

13.3.3.2. Prevalence

13.3.3.2.1. *Salmonella*

The USDA-FSIS Raw Pork Product Sampling Study (Phase I from May 2015 to November 2015 and Phase II from June 2017 through May 2018) generated *Salmonella* prevalence data (Scott *et al.*, 2019).

Table 45: USA, Pork – Summary of USDA-FSIS Raw Pork Product Sampling Study – *Salmonella*

Study	Sample Numbers	Positives (%)
Phase I	1,200	200 (16.7%)
Phase II	4,014	545 (13.6%) This was split dependent on product type with prevalence of: • 21.2% in comminuted products • 8.3% in intact products • 6.5% in non-intact products

In 2001, Zhao *et al.* reported a *Salmonella* prevalence in raw pork in the Washington DC area of 3.3% (209 samples with 7 positives).

13.3.3.2.2. *Campylobacter*

A report in 2001 looked at raw meats in the Washington DC area and reported 3 positives from 181 samples (1.7%) (Zhao *et al.*, 2001).

13.3.3.2.3. STEC

The USDA-FSIS Raw Pork Product Sampling Study (Phase I from May 2015 to November 2015 and Phase II from June 2017 through May 2018) generated STEC prevalence data (it is assumed that STEC would mean the USDA “big 6” of O157 plus O26; O45; O103; O111; O121 and O145).

Table 46: USA, Pork – Summary of USDA-FSIS Raw Pork Product Sampling Study – STEC

Study	Sample numbers	Positives (%)
Phase I	200	10 (5%) This was split dependant on product type with prevalence of: • 5.4% in comminuted products • 4.9% in intact products • 0% in non-intact products
Phase II	1,393	3 (0.2%) This was split dependent on product type with prevalence of: • 0.44% in comminuted products • 0% in intact products • 0% in non-intact products

Note: in Phase one only non-O157 STEC was tested, in phase 2, O157 testing was included.

A paper by Magwedere *et al.* (2013) looked at the incidence of STEC in pork in Pennsylvania and Virginia. They tested 16 samples and found 8 positives (50% prevalence, made up of 6 x O121, 1 x O103 and 1 x O157), however, none were found to contain *stx* genes and they were not considered to be STEC.

Jung *et al.* (2019) reported on a survey of pork at retail stores in the mid-Atlantic region of the USA. 514 raw pork samples were tested (395 ground / non-intact samples, and 119 intact samples). These were done for *E. coli* O157 and the USA “big 6” STEC (O26, O45, O103, O111, O121, O145). Whilst presumptive positives were found, none were confirmed.

13.3.3.2.4. *Trichinella*

A 2018 paper by the USDA Animal and Plant Health Inspection Service (APHIS) considered the seroprevalence of *Trichinella* antibody in US pigs (APHIS, 2018). This reported that in the first year of the study (1990) 3,048 pig blood samples were collected and 5 tested positive. In 2012 (the last year considered in the paper), 5,705 pig blood samples were tested. One positive was obtained.

13.4. Poultry

13.4.1. Market overview

The United States of America (USA) is one of the main exporters with 8.4% market share (3.4 million tonnes) of poultry meat. Poultry from the USA is not imported into the UK or the EU (EC, 2020). The USA is the world's largest poultry meat producer, with 18 percent of global output (FAO, 2021). Most chicken processing is carried out in Georgia, Arkansas and Alabama, and turkey processing in Minnesota, North Carolina and Arkansas (NAMI, 2017).

13.4.2. Production processes

The National Chicken Council (a trade body) indicates that independent farmers are contracted to a chicken production and processing company to raise chickens. More than 90% of all chickens raised for meat in the US (broiler chickens) are raised by contract farmers. The company with which the farmer contracts provides the chickens, the feed, veterinarian care and technical advice, while the poultry farmer provides the day-to-day care of the birds, land and housing on which they are raised, and utilities/maintenance of the housing. Farmers are paid according to the weight gained by the flock, the quality and quantity of their flock, as well as how efficiently the chickens are raised. The use of growth hormones or steroids and inappropriate use of antibiotics (controlled by legislation) are not permitted. All farmers are required to comply with Chicken Guarantees animal welfare standards and are reported to be held to standards of animal welfare that ensure sound animal husbandry. Non-compliance may lead to the termination of a farmer's contract. These factors will be based on the contract between the integrator and the farmer. Livestock and poultry procurement and marketing practices are regulated by the U.S. Department of Agriculture's Grain Inspection, Packers and Stockyards Administration (GIPSA), which administers and enforces the Packers and Stockyards Act to protect farmers, ranchers and consumers (National Chicken Council, Chicken Check In).

13.4.2.1. Biosecurity

Each company must have a written flock health and welfare monitoring plan developed in consultation with a veterinarian. This plan should include, but is not limited to, information about: immunization programs (including training of those who handle birds for immunizations or blood testing), daily flock checks, daily mortality/morbidity monitoring which should include detailed culling parameters, euthanasia procedures, gait monitoring, and when, how, and under what circumstances a producer reports a disease or other health situation to the appropriate person for determination of corrective action. This person may be the veterinarian, service technician, live production manager, or other qualified individual.

Guidance is given by National Poultry Improvement Plan Program Standards' Biosecurity Principles. Poultry sheds should remain empty for at least 10 days between flocks ; this is recommended but may depend on other factors such as bad weather or cleanout schedules. This time is similar to recommendations made in UK biosecurity guidance.

Farmers should only use disinfectants that are registered by the US Environmental Protection Agency (EPA).

Newly updated guidance (APHIS, 2020) gives extensive guidelines on biosecurity.

There is guidance on pathogen reduction and how to demonstrate competence/verification testing from the FSIS. In addition, various guidance and information, including relating to biosecurity, is available via the Animal and Plant Health Inspection Service (APHIS, 2020).

13.4.2.2. Transport and slaughter

Slaughter of animals cannot take place unless an FSIS inspector is present. To be granted FSIS inspection onsite, establishments must prove they have an adequate HACCP plan and sanitation procedure in place, they have done a hazard analysis and that they comply with all FSIS requirements. The FSIS inspector is required to verify this and if found not to be compliant have the authority to take regulatory action to stop processing (FSIS, 2013a).

13.4.2.3. Ante and post-mortem inspection

Flocks are inspected by the Food Safety and Inspection Service (FSIS). Primarily these inspections are conducted at the slaughterhouse instead of on the farm to prevent spread of diseases. A Public Health Vet (PHV, equivalent of OV in EU) oversees ante mortem inspection which must be performed before daily slaughter begins.

Poultry which is condemned from the ante-mortem inspection must not enter the official establishment and are to be disposed of. Birds which are dead on arrival must be identified, counted, weighed and the number recorded on FSIS Form 9061-2.

Food inspectors may carry out the above duties but if they suspect there is a contagious disease which may be transmissible to humans, they must involve a veterinarian. Birds will either be released for further treatment or condemned.

There is a New Poultry Inspection System (NPIS) being implemented in the US, where plants can request to be converted to the new standard. This is optional. The optional NPIS requires poultry companies do their own sorting or quality control before chicken carcasses are presented to FSIS inspectors, who in turn are to more frequently remove birds from the evisceration line for close food safety examinations, take samples for testing, check plant sanitation, verify compliance with food safety plans, observe live birds for signs of disease or mistreatment, and ensure plants are meeting all applicable regulations. Unions representing meat inspectors, however, opposed the optional NPIS and the pilot program that preceded over various concerns including increased line speeds. Line speeds under NPIS are capped at 140 birds per minute, which USDA says is consistent with existing inspection programs.

All chickens found in retail stores are either inspected by USDA or by State systems which have standards equivalent to the Federal government. Each chicken and its internal organs are inspected for signs of disease. The “Inspected for wholesomeness by the U.S. Department of Agriculture” seal ensures the chicken is free from visible signs of disease.

13.4.2.4. Chilling and other intervention steps

USDA requires birds to be chilled down by a specific time depending on their weight. The exception is if the carcass is to be frozen or cooked immediately onsite. During further processing and packaging operations the internal temp of the carcass may rise to 55°F (12.8°C) provided that immediately after packaging the poultry is stored under 40°F(4.4°C) or in a freezer. Poultry held at the establishment for longer than 24hrs should be held at 36°F (2.2°C) or lower. The most common method of chilling is ice bath immersion. FSIS stipulate that water cannot be absorbed by the carcass unless necessary to achieve food safety by chilling down in time. Statement on packaging about added water is required.

Various categories of pathogen reduction treatments (PRTs) are permitted.

FSIS conducted a survey of PRTs used in poultry processing in 2014, and the results showed that most use chlorine/chlorine derivatives to wash during evisceration (65%) and organic acids/chlorine derivatives during on-line reprocessing (35% and 35% respectively).

13.4.3. Microbiology

13.4.3.1. Microbiological criteria

In the USA, the United States Department of Agriculture Food Safety and Inspection Service (USDA-FSIS) continuously samples poultry establishments producing young chicken and turkey carcasses, and raw chicken parts, so that it can more closely monitor an establishment's process control over time according to the *Salmonella* Verification Testing Program (FSIS, 2019d).

FSIS also continuously samples not-ready-to-eat (NRTE) comminuted chicken and turkey products for *Salmonella*.

It should be noted that the USDA does not collect data from establishments that produce 1,000 lbs (approx. 455 kg) or less of each product per day, or slaughter 20,000 head or fewer. Data is not available for these sized establishments.

USDA-FSIS posts on its website, the category status of individual establishments for pathogen reduction performance standards for *Salmonella* in young chicken carcasses, young turkey carcasses, raw chicken parts, and NRTE comminuted chicken and turkey products, based on FSIS verification sampling results from one 52-week window, but not to include follow-up sampling. As outlined in a notice by FSIS regarding the proposed change (FSIS, 2019f), the category definitions under verification sampling are as follows:

- Category 1: Establishments that have achieved 50 percent or less of the maximum allowable percent positive during the most recent completed 52-week moving window.
- Category 2: Establishments that meet the maximum allowable percent positive but have results greater than 50 percent of the maximum allowable percent positive during the most recent completed 52-week moving window.
- Category 3: Establishments that have exceeded the maximum allowable percent positive during the most recent completed 52-week moving window.

Individual windows are defined as 52 consecutive Sunday-to-Saturday weeks. Category status is determined based on 52 weeks of data, i.e., the last completed 52-week moving window, ending on the last Saturday of the previous month.

For *Campylobacter* testing, the USDA began using an enrichment method, rather than direct plating, to detect *Campylobacter* in August 2019, and stopped assessing whether establishments met the previously current criteria. This will continue until USDA consider that they have sufficient data using the new method and have new *Campylobacter* performance standards in place. The new method has a lower limit of detection than the direct plating method used previously.

The method used for *Salmonella* testing of whole carcasses, rinses the whole bird in 400ml diluent, then takes 30ml of this and mixes with 30ml of Buffered Peptone Water and begins the 2-stage incubation (FSIS, 2019f).

Prospective new *Campylobacter* performance standards for comminuted products are given in FSIS, 2019e.

USDA-FSIS Performance Standards for *Salmonella* and *Campylobacter* are given in Table 47.

Table 47: USA, Poultry – USDA-FSIS Performance Standards for *Salmonella* and *Campylobacter*

Product	Max acceptable % positive: *Salmonella*	Max acceptable % positive: *Campylobacter*	Performance standard: *Salmonella*	Performance standard: *Campylobacter*
Broiler Carcasses	9.8	15.7	5 of 51	8 of 51
Turkey Carcasses	7.1	5.4	4 of 56	3 of 56
Comminuted Chicken	25.0	1.9	13 of 52	1 of 52
Comminuted Turkey	13.5	1.9	7 of 52	1 of 52
Chicken Parts	15.4	7.7	8 of 52	4 of 52

Source: (FSIS, 2019d)
Note: The table shows results over the USDA-FSIS weekly sampling window and the percentage allowable positives (e.g. for *Salmonella* in broiler carcasses, the performance standard is no more than 5 over 51 sample weeks, which is equivalent to 9.8% positive prevalence).

13.4.3.2. Prevalence

USDA-FSIS publish data, reports and regular updates on their website.

13.4.3.2.1. *Salmonella*

In the case of *Salmonella*, data is presented in USDA-FSIS reports up to 2014 and show *Salmonella* prevalence in young chicken was at 3.8% (FSIS, 2014b). The USDA-FSIS also produce regular updates on the number of producers that comply/do not comply with their performance criteria. The recent data from January 2019 to January 2020 are shown below for young chicken carcasses, chicken parts and comminuted chicken (FSIS, 2019d).

It should be noted that sites falling into Category 1 and 2 meet the USDA criteria for *Salmonella*, but sites falling into Category 3 do not meet current criteria. The latter sites

face a requirement to assess the causes of the failure and do continued sampling, if a failure of HACCP is believed to have occurred, enforcement action can be taken.

The data for the last year indicates that 12.3% of young chicken carcass producers did not meet the USDA criteria for *Salmonella* in 2019, i.e. they exceeded the number of allowable positives within a 52-week moving window. However, the size of the site had a large impact on results, with smaller sites being markedly worse than larger ones.

Table 48: USA, Poultry – Young Chicken Carcasses Establishment Aggregate Categories for Sample Collection Period January 27, 2019 through January 25, 2020 re *Salmonella*

Type of Establishment	All Establishments	All Establishments	Large Establishments	Large Establishments	Small Establishments	Small Establishments	Very Small Establishments	Very Small Establishments
Category	Number	%	Number	%	Number	%	Number	%
Category 1	122	62.56	93	67.39	21	60	8	36.36
Category 2	49	25.13	37	26.81	9	25.71	3	13.64
Category 3	24	12.31	8	5.8	5	14.29	11	50
TOTAL	195	100	138	100	35	100	22	100

Table 49: USA, Poultry – Chicken Parts Establishment Aggregate Categories for Sample Collection Period January 27, 2019 through January 25, 2020 re *Salmonella*

Type of Establishment	All Establishments	All Establishments	Large Establishments	Large Establishments	Small Establishments	Small Establishments	Very Small Establishments	Very Small Establishments
Category	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Category 1	285	70.54	111	70.7	133	70.37	41	70.69
Category 2	73	18.07	38	24.2	27	14.29	8	13.79
Category 3	46	11.39	8	5.1	29	15.34	9	15.52
TOTAL	404	100	157	100	189	100	58	100

Table 50: USA, Poultry – Comminuted Chicken Establishment Aggregate Categories for Sample Collection Period January 27, 2019 through January 25, 2020 re *Salmonella*

Type of Establishment	All Establishments	All Establishments	Large Establishments	Large Establishments	Small Establishments	Small Establishments	Small Establishments	Very Small Establishments
Category	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Category 1	20	38.46	4	40	12	33.33	4	66.67
Category 2	10	19.23	2	20	7	19.44	1	16.67
Category 3	22	42.31	4	40	17	47.22	1	16.67
TOTAL	52	100	10	100	36	100	6	100

13.4.3.2.2. *Campylobacter*

The USDA-FSIS has stopped collecting data on the *Campylobacter* reduction programme due to a change in test methodology (it will resume when they collect enough data), The last data available runs from May 2017 to July 2018 (FSIS, 2019d).

Category 1 and 2 meets the USDA criteria, whilst category 3 does not. This indicates that in the latest dataset 1.05% of young chicken carcass producers did not meet the USDA criteria for *Campylobacter*, i.e. they exceeded the number of allowable positives within a 52-week moving window. However, as with the *Salmonella* data, smaller sites had poorer results than larger ones.

Table 51: Young Chicken Carcasses for sampling period May 7, 2017 to July 28, 2018 re Campylobacter

Type of Establishments	All Establishments	All Establishments	Large Establishments	Large Establishments	Small Establishments	Small Establishments	Very Small Establishments	Very Small Establishments
Category	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Category 1	183	95.81	132	100	37	92.5	14	73.68
Category 2	6	3.14	0	0	3	7.5	3	15.79
Category 3	2	1.05	0	0	0	0	2	10.53
TOTAL	191	100	132	100	40	100	19	100

13.5. Antimicrobial resistance

The USDA Antimicrobial Resistance Action Plan (USDA, 2014) is designed to look at purposes, impacts and patterns of antibiotic use in food producing animals. To monitor their use and identify management strategies.

It had been noted by CDC that since 2017 drugs that are important for human health are no longer allowed to be used for growth promotion or feed efficiency in the USA (CDC, 2020a). According to FDA's Guidance for Industry #213, all antimicrobial drugs listed in Appendix A to Guidance for Industry #152 are considered to be "medically important" (FDA, 2003; FDA, 2013). In 2021, FDA published a concept paper outlining a potential approach for updating FDA's current list of antimicrobial drugs ranked by their important in human medicine (FDA, 2021). It has been reported that USA accounts for 13% of global consumption of antibiotics for food animals, the second highest in the world after China (MoHFW 2017).

In terms of antimicrobial use, Lhermie *et al.* (2019) reported on FDA data from 2016 that indicated that dairy and beef cattle accounted for approximately 50% of non-medically and medically important antimicrobial use in food animal production. An FDA report (2019) reporting on 2018 data indicates that this figure for cattle had reduced slightly to 42%. The report notes that pork production accounted for approximately 39% of medically important antimicrobial use in food animal production in the USA in 2018, while the corresponding figure for chicken was 4%. The FDA data on sales of antimicrobials for use in food producing animals does not include sheep or lamb. Also, FDA report does not express the quantities sold per kg body mass.

Hillerton *et al.* (2017) estimated antimicrobial use in the US in food animals, excluding horses, at 275.3 mg/PCU based on data from 2012. O'Neill (2015) ranked the US as the sixth-highest for antibiotic use in agriculture among the 29 countries examined at the time of the review.

The USA operates the National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS) through the CDC that monitors and tracks antimicrobial resistance in the USA (CDC, 2020b). Data from NARMS can be obtained and compared. NARMS data is extensive and can be searched at the FDA NARMS website. It would appear that NARMS does not collect data on AMR from lamb isolates but concentrates on cattle,

pigs, chickens and turkeys (and their meat). Outside of some very local reports, no national data on AMR in sheep/lamb isolates could be found.

Data from NARMS can be easily compared and, if information on AMR in the marker organism *E. coli* is selected, this is reported to have stayed at the same level from 2000 to 2015 (Roth *et al.*, 2019).

Generally, data on antimicrobial resistance of *E. coli* isolates from cattle and pigs does not show a downward trend. From 2011 to 2018, the trend for cattle was upwards for most major antibiotics – for tetracycline (from 17.7% (*n* = 215) to 30.8% (*n* = 1,754)), streptomycin (from 6.5% to 15.8%), ampicillin (from 3.7% to 7%), sulfamethoxazole (from 7.9% to 14%). This is most likely because more cecal isolates were included. If only ground beef is considered, the numbers are more or less stable throughout the years.

Over the same period, similar upwards trend was observed for resistance in *E. coli* from swine isolates for most major antibiotics. For instance, for tetracycline, resistance increased from 46.6% (*n* = 146) in 2011 to 62.8% (*n* = 800) in 2018, for ampicillin (from 13% to 21.8%), for sulfamethoxazole (from 10.3% to 18.4%), for streptomycin (from 15.1% to 26.1%). On the other hand, for *E. coli* isolates from chicken host a downwards trend can be seen. For example, from 51% (*n* = 955) to 29.5% (*n* = 634) for sulfamethoxazole, from 44.5% to 31.2% for tetracycline, from 41.3% to 23.5% for gentamicin etc. All other combinations can be checked on NARMS. The data goes back to 2000.

The observed decrease in the prevalence of antimicrobial resistance in poultry could be attributed to reported significant reductions in the use of antibiotics within the US poultry industry in recent years (2013 to 2017) (Mindwalk, 2017). Indeed, the poultry industry appears to lead the way in the USA in reducing antibiotic use. The following reduction in use of medically important water-soluble antimicrobials was highlighted:

- penicillin use decreased approximately 21% between 2013 and 2017 and approximately 42% since the peak in 2015
- tetracycline use decreased approximately 47% between 2013 and 2017
- lincomycin use decreased approximately 28% between 2013 and 2017 and approximately 58% since the peak in 2015
- sulfonamide use decreased approximately 72% between 2013 and 2017

- tylosin use decreased approximately 46% between 2013 and 2017

There are a range of projects on-going in the USA considering prevalence of AMR in poultry derived organisms (ARS, 2020).

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14. Brazil

14.1. Beef

14.1.1. Market overview

Brazil is officially divided into five regions; North, Northeast, Centre-West, Southeast and South. In 2019, Brazil had 238 million cattle which is the largest number of any country. About 60% of cattle herds are located in the Centre-West and Northern regions (FAS, 2019). Livestock is mostly grass fed, and 10% is by feedlot systems. This is changing with the potential for feedlots to double in the next five years. There are also some semi-confinement systems where livestock is fed grain on pasture, usually in the dry seasons where grass is less available. Brazil is not a large importer of beef from other countries. (FAS, 2019). Due to long distances when exporting, beef is frozen for shipments.

14.1.2. Production processes

14.1.2.1. Biosecurity

Information on biosecurity was limited for red meat in Brazil, with little guidance or studies found to evidence best practice. The Department of Animal Health (DSA) runs disease eradication programmes which may help to reduce levels of incidence. Specific procedures for cattle farmers to follow on their ranches or feedlots were not identified.

14.1.2.2. Transport and slaughter

Slaughter is overseen by the Federal Inspection Service (SIF). If animals are found to be in poor health and fail the ante-mortem inspection, then they must go through emergency slaughter. A Federal Agricultural Inspector must be present during this process. Samples from suspect animals showing signs of disease must be collected for analysis. If an animal goes through emergency slaughter and is still deemed fit for human consumption, then this may be permitted providing they are inspected post-mortem.

Animals must be washed to remove extraneous dirt from their hides. Bleeding must be done as completely as possible; only then can any further cutting operations begin.

Legislation specifies that there is a minimum bleeding time in supplementary norms, but no specific time could be found (Brazil Government, 2017).

14.1.2.3. Ante and post-mortem inspection

Ante-mortem inspection is undertaken by competent officials employed by the SIF such as Agricultural Inspectors. They may be assisted by Sanitary and Industrial Inspection Agents for Animal Products (AISIPOAs) and auxiliaries (Brazil Government, 2017). A study in Brazil showed that federal inspection by SIF may result in a lower number of Brucellosis cases compared to state or municipal inspection (Mioni *et al.*, 2018).

Inspectors are required to examine food chain information, the animal's behaviour and general health, as well as any signs of infection or disease. These inspections should be done within 24 hours prior to slaughter and be repeated if slaughter is delayed. Brazilian regulation lays down guidance for inspecting animals to be slaughtered for beef including the number of abnormalities allowed on carcasses and the appropriate treatment they are given as a result. Defects which are detailed in legislation are similar if not the same as UK guidelines; for example, bruised, pale, bloody or exudative (Brazil Government, 2017).

Suspect cases are to be examined by a qualified veterinarian. If animals are found to be infected, then they must be slaughtered separately from the rest of the herd. If the illness is contagious then the animal health service for the region must be contacted and measures to contain the spread of the illness are to be put in place. SIF have the power to seize stock and test if they suspect that, as a result of the ante-mortem inspection, the declared use of treatments and withdrawal periods does not match up to the condition the live animals are in. They are allowed to request the food chain information up to 24 hours before arrival at the slaughterhouse (Brazil Government, 2017).

A DG Santé report from 2018 found that slaughterhouse staff perform post-mortem inspection in some places which is not in line with the EU's requirement for federal inspection only apart from in certain situations for poultry and rabbit meat (DG Santé, 2018).

14.1.2.4. Chilling and other intervention steps

Carcasses or parts of must be chilled before being frozen. When chilled in air the carcasses or parts must be hung and arranged with sufficient space between them. In the event of infectious diseases, a disinfection procedure must be in place for the facility (Brazil Government, 2017). No specific times and temperatures were found for red meat. 7°C was identified as a key target for poultry so this may also be applicable (Bailone *et al.*, 2016).

14.1.3. Microbiology

14.1.3.1. Microbiological criteria

Brazil publishes a full set of microbiological criteria. Currently, this is as part of Normative Instruction No. 60/2019 which came into force on 26th December 2020.

Table 52: Brazil – Microbiological criteria (from 26th December 2020)

Food Category	Microorganism	*n*	*c*	*m*	*M*
Raw meat, aged or not, seasoned or not, chilled or frozen, vacuum packed or not	*Salmonella* /25g	5	0	Absence	-
	Escherichia coli /g	5	2	10	100
	Aerobic mesophiles /g	5	3	100,000	1,000,000
Minced meat, moulded raw meat products, seasoned or not, chilled or frozen	*Salmonella* /25g	5	0	Absence	-
	Escherichia coli /g	5	2	10	100
	Coagulase positive *Staphylococci* /g	5	2	100	10,000
	Aerobic mesophiles /g	5	3	100,000	1,000,000

Source: Normative Instruction No. 60/2019
n = number of samples to be tested from a batch/lot
m = criterion below which the batch is considered acceptable
M = criterion above which the result for any sample(s) would make the batch unacceptable
c = number of samples whose results can be between *m* and *M* for the batch to be acceptable

14.1.3.2. Prevalence

14.1.3.2.1. *Salmonella*

The most recent information obtained was in Bier *et al.* (2018). This was a survey of beef samples taken at 3 points in the slaughter line (post skinning, post washing and post cooling) at three slaughterhouses in Brazil that export meat. Detection method was the ISO 6579:2002 (ISO method for *Salmonella* detection).

The paper reports that *Salmonella* was detected in only one slaughterhouse. Prevalence was 2.2% after skinning (*n* = 90), 1.1% after washing (*n* = 90) and 4.4% after cooling (*n* = 90) (presumption of possible cross contamination during the cooling process).

Previous studies in beef slaughterhouses (Cossi *et al.*, 2014) have obtained very similar results with a maximum prevalence after washing of 1.4% (*n* = 209).

14.1.3.2.2. *Campylobacter*

The most recently available reports on *Campylobacter* in beef in Brazil is in Lopes *et al.*, 2018. These authors tested 100 beef samples at retail in Sao Paulo. Testing was done via ISO 10272-1 (a presence or absence test, not enumeration). All beef samples tested were negative for *Campylobacter*.

14.1.3.2.3. STEC

A full systematic review of STEC in Brazil was published in 2019 (Castro *et al.*, 2019). Results from this review for beef are given here.

Table 53: Brazil, Beef – Summary of prevalence data – STEC

State	Number of samples	Prevalence	Serotype or genes amplified
São Paulo	204 bovine carcass swabs	27.5% (rainy season), 17.5% (dry season)	*stx*1 and *stx*2
São Paulo	250 raw ground beef samples	1.6%	O93:H19, O174:HNT
São Paulo	91 beef samples	2.1%	*stx*2
São Paulo	70 raw kibbeh samples	2.8%	O125:H19, O149:H8
São Paulo	552 meat products samples	0%	-
Rio Grande do Sul	5 beef jerky samples	0%	-
Mato Grosso	80 samples	10%	O83:H19, O26:HNT, O73:H45, O8:H21, O79:H7, O113:H21, O22:H16, O117:H7, O21:H19, O132:H21

14.2. Poultry

14.2.1. Market overview

Brazil is one of the main exporters at 3.7 million tonnes of poultry meat (Brazilian Chicken, 2016). Due to the distances involved, poultry from Brazil is typically transported frozen.

14.2.2. Production processes

In Brazil, it is reported by the national trade association that approximately 90% of industrial poultry production is under the integrated system. Poultry farmers are provided by industry with the assistance of agronomists and veterinarians and the supply of the day-old chicks, feed and medication. It is reported that poultry farmers raise the birds following the animal welfare guidelines, biosecurity and animal health procedures. Such rules and standards are monitored by the companies. Traceability of the product from farm to the consumer is reported to be guaranteed (Brazilian Chicken, 2016).

The process is generally the same as that in the UK/EU, the same conditions are considered. No specific information was identified about line speeds and number of operatives present for inspection.

14.2.2.1. Biosecurity

Normative Instruction No. 12/2017 has been newly released to bring welfare standards up to date.

The National Poultry Program for Sanitary Control (PNSA) is available to assist with controlling poultry health. In addition, the Pathogen Reduction Program (PRP) for *Salmonella* and PNCRC for control of residues and contaminants are also available.

14.2.2.2. Transport and slaughter

No specific details were identified.

14.2.2.3. Ante and post-mortem inspection

An audit was undertaken by DG Santé in Brazil in May 2017 (DG Santé, 2017b), and a follow-up audit in Jan-Feb 2018 (DG Santé, 2018) relating to beef, horse and poultry meat.

The initial report concluded that “As designed, the Brazilian official control system for the production of beef, horse and poultry meat, and products derived therefrom to be exported to the EU has the capacity to provide the necessary guarantees. However, the shortcomings detected during the audit demonstrate that, for all sectors with the exclusion of beef, the system is not fully or effectively implemented, and this compromises the reliability of export certification”. The systems were found not to be effective in detecting and acting on significant non-compliances in the performance of the CAs at the local/state level. Establishments were not always under the supervision of official veterinarians, the list of approved establishments for export to the EU was not up to date and, in some cases, arrangements did not ensure staff undertaking official controls were free from conflict of interest.

Twenty-one food producing establishments, of which four were listed for EU export of meat and products, in three different states were involved in a police investigation referred to as “Carne fracas”. MAPA suspended the activities in all of them and the four approved for EU exports were delisted from the EU list.

A previous audit was conducted in 2013 (DG Santé, 2013c) when, in relation to poultry meat, problems were noted on *Salmonella* testing, ante-mortem and post-mortem inspection, Hazard Analysis of Critical Control Points (HACCP) controls, animal welfare, accreditation of official laboratories, listing of establishments and actions in cases of RASFF notifications. Written guarantees were received from the CA in relation to the implementation of those recommendations and the report comments that, on paper, they were considered satisfactory.

The follow up audit in 2018 (DG Santé, 2018) noted the actions being taken by the Brazilian authorities who are in the process of introducing new legislation and amending their systems.

14.2.2.4. Chilling and other intervention steps

Carcasses must present a maximum temperature of 7°C, no minimum time is specified but if immersion chilled then the carcass can only have 30 mins max in the water.

In terms of pathogen reduction treatments, chlorine derivatives are commonly used in pre-chill and chill tanks, but other chemical treatments such as organic acids, alkyl dimethyl benzyl ammonium chloride and sodium methyl sulphate are not permitted. Brazil only appears to specify chlorine derivatives permitted at max 5ppm.

14.2.3. Microbiology

14.2.3.1. Microbiological criteria

Brazil has testing and microbiological criteria legislation from the Ministry of Agriculture Livestock and Supply (MAPA) covering poultry carcasses. It would appear that there is a requirement to use accredited laboratories to do the testing and predominantly this is for *Salmonella* not *Campylobacter*.

Brazil has microbiological criteria for poultry meat. These have been put forward by the Health Ministry, National Health Surveillance Agency (Ministerio da Saude, Agência Nacional de Vigilância Sanitária, ANVISA). The current microbiological limits for poultry are established in Normative Instruction No. 60/2019 which came into force on 26 December 2020.

Each state in Brazil is required to participate in the PEMQSA (Programas de Monitoramento da Qualidade Higiênico Sanitária de Alimentos) program to monitor the microbiological quality of food, and this is overseen by ANVISA.

Table 54: Brazil – Current microbiological criteria (from 26th December 2020)

Raw poultry meat, seasoned or not, chilled or frozen:

Organism	*n*	*c*	*m*	*M*
Salmonella Enteritidis /25g	5	0	Absent	-
Salmonella Typhimurium /25g	5	0	Absent	-
Escherichia coli /g	5	3	500	5,000
Aerobic mesophiles /g	5	3	100,000	1,000,000

Raw meat products made from ground or minced poultry, seasoned or not, encased or not, chilled or frozen:

Organism	*n*	*c*	*m*	*M*
Salmonella Enteritidis /25g	5	0	Absent	-
Salmonella Typhimurium /25g	5	0	Absent	-
Escherichia coli /g	5	3	500	5,000
Aerobic mesophiles /g	5	3	100,000	1,000,000

Source: Normative Instruction No. 60/2019
n = number of samples to be tested from a batch/lot
m = criterion below which the batch is considered acceptable
M = criterion above which the result for any sample(s) would make the batch unacceptable
c = number of samples whose results can be between *m* and *M* for the batch to be acceptable

Note: The requirements for *Salmonella* Enteritidis and *Salmonella* Typhimurium are the same as the requirements for the European Union.

In Brazil, sampling of poultry carcasses is done by taking a 25 g sample of skin and muscle excision (SME) from the wings, neck, and pericloacal parts.

The testing plans appear to be linked to the size of the killing plant, different sizes of plants being give a different letter code according to the number of poultry slaughtered each day as indicated below:

Table 55: Brazil – Codes *vs* size of number of poultry slaughtered

Classification	Number poultry (chicken) slaughtered per day
P	Below 50,000
M	Between 50,001 and 100,000
G	Between 100,001 and 200,000
GG	Above 200,001

The criteria are noted in Normative Instruction No. 20/2016.

Table 56: Brazil – Sampling for auto-control (i.e. by the supplier) (carcasses)

Classification	*n*	*c*	Cycles per year	Samples per week
P	8	2	6	1
M	26	6	4	2
G	51	12	5	5
GG	51	12	10	10

Source: Normative Instruction No. 20/2016
n = number of samples
c = number of results that can be greater than the criterion but still be acceptable

As an example of how this system works:

- Establishments graded “P” would take 1 sample per week over 8 weeks (one cycle), then start the next cycle. 6 cycles per year (covering 48 weeks) would be run.
- Establishments graded “M” would take 2 samples per week over 13 weeks (26 samples total) and operate this cycle 4 times per year covering 52 weeks).

Table 57: Brazil – Official sampling (of establishments)

Classification	*n*	*c*	Cycles (per year)	Samples (per n week)
P	8	2	2	1 sample per 3 weeks
M	8	2	2	1 sample per 3 weeks
G	8	2	3	1 sample per 2 weeks
GG	8	2	3	1 sample per 2 weeks

14.2.3.2. Prevalence

In Brazil, studies showed *Campylobacter* to be widespread throughout the processing chain including birds (faeces, caecum, intestine, cloaca and feathers), chicken litter, surfaces, equipment and water on the farm and industry. *C. jejuni* was the most prevalent species followed by *C. coli* and *C. upsaliensis* (Silva *et al.*, 2018). A study in 2015 found 37.1% (*n* = 105) of chicken carcasses were positive (Perdoncini *et al.*, 2015).

The number of studies on prevalence, characterisation and enumeration of *Campylobacter* in Brazilian poultry is reported to be low compared to other countries. Whilst a high number of positive samples of chicken and chicken products have been reported, the number of foodborne disease outbreaks associated with *Campylobacter* have been reported to be low (Silva *et al.*, 2018).

The most recent data available from Brazil comes from DIPOA's Annual Report of Education Programs for Food Control of Animal Origin (DIPOA, 2019).

14.2.3.2.1. *Salmonella*

In 2018, for the official verification, 2,791 samples of chicken carcasses were analysed, with the presence of *Salmonella* spp. of 12.71% (352 / 2,791).

The report goes on to state that, in 2018, there was a reduction of almost 30% in the occurrence of *Salmonella* spp. in official samples of chicken carcasses compared to the previous year.

14.2.3.2.2. *Campylobacter*

In 2018, DIPOA completed study to estimate prevalence of *Campylobacter* in chicken carcasses in slaughterhouses with SIF (Serviço de Inspeção Federal). Of a total of 816 samples analysed, 34.3% (280 / 816) showed a *Campylobacter* above 500 cfu / carcass.

14.3. Antimicrobial resistance

In 2018, the Ministry of Health published the National plan of action for the prevention and control of resistance to antimicrobials in the framework of One Health, 2018-2022.

The Ministry of Agriculture, Livestock and Food Supply (MAPA) is responsible for the registration and supervision of veterinary products while acceptable daily intakes and maximum residue limits of veterinary medicines in food are established the Brazilian National Health Surveillance Agency (ANVISA).

Cardoso (2019) has noted that the use of antimicrobials for therapeutic, prophylactic and metaphylactic purposes is not prohibited in Brazil, whilst some antimicrobials are allowed as growth promoters in defined livestock species. It is noted that in past years many antibiotics have been withdrawn as growth promoters by specific legislation.

A review of antimicrobial resistance in Brazilian farmed animals produced by Rabello *et al.* (2020) listed various regulations restricting the use of antimicrobials for animal use. As such, the use of avoparcin was prohibited in 1998; antimonial compounds in 2002; chloramphenicol and nitrofurans (including veterinary clinical use) in 2003; olaquindox in 2004; carbadox in 2005, amphenicols, tetracyclines, beta-lactams (benzylpenicillin and cephalosporins), quinolones, and sulfonamides in 2009; spiramycin and erythromycin in 2012; and colistin in 2016. Recently, the use of the additives tylosin, lincomycin, and tiamulin was also prohibited. Virginiamycin and bacitracin are the remaining additives allowed for use.

A report from Wageningen UP Livestock Research (Bokma, 2014) covering antibiotic use in Brazilian broiler and pig production concluded that there was no information available about the amounts of veterinary antibiotics sold or used in Brazil. The researchers noted that growth promoters were commonly used on broiler farms for the home market, but that production for the EU was segregated and did not use growth promoters. The quantitative information about antibiotic use from integrators or drug manufacturing plants was not available to third parties but it was noted that, based on qualitative information, the therapeutic use of antibiotics in Brazilian broiler production (1 out of 40 flocks in 2006) was estimated to be substantially lower than the average on Dutch broiler farms in 2011 (i.e. average Dutch broiler flock was treated for 3.4 days with antibiotics). On the

other hand, this could be partially because of the use of antibiotics as growth promoters in Brazil.

More recently, Cardoso (2019) also noted that official data on the volume of antimicrobials used in animal production is not publicly available in Brazil. However, it has been reported in other sources that Brazil accounts for 9% of global consumption of antibiotics for food animals, the third highest in the world after China and the USA (MoHFW 2017).

Roth *et al.* (2019) reported that there is no central microbiology reference laboratory in Brazil and thus no regular AMR monitoring data is available and consistent standardised data is lacking.

In the last ten years, some studies have evaluated antimicrobial resistance of *E. coli*, *Salmonella,* and *Listeria monocytogenes* isolates obtained from cattle carcasses, beef-products, and meat-processing environments. Some multidrug resistance has been noted in *E. coli* isolates (including O157), similarly in *Salmonella* results are varied some showing susceptibility, others resistance.

Recent reports have raised concerns over the level of antimicrobial resistance in farmed animals in some countries. A review published in 2019 (Van Boeckel *et al.*, 2019) described the south coast of Brazil as a regional “hotspot” of resistance in common indicator organisms (i.e. an area where the proportion of antimicrobial compounds with resistance higher than 50% is above 0.4). Some of the test results used in the review included a research by Rodolpho & Marin (2007) who observed prevalence of *E. coli* isolates from ground beef, grinding-machines and hands of meat manipulators to tetracycline (76.6%), amoxicillin (64.1%), cephalothin (58.8%), streptomycin (51.2%), nalidixic acid (31.3%), ampicillin (23.6%) (*n* = 287).

Rigobelo *et al.* (2011) found that 84% of *E. coli* isolates from cattle carcasses were resistant to cephalothin, 45% to streptomycin, 42% to nalidixic acid, and 20% to tetracycline (*n* = 120). 24% of the isolates were resistant to all 10 antibiotics tested.

Silva *et al.* (2014) found that all isolates of *Salmonella* spp. from beef carcasses were susceptible to 15 antimicrobials tested although this is not in line with the previous findings.

Lopes *et al.* (2018) reported that *Campylobacter* isolates from chicken meat were commonly resistant to nalidixic acid and ciprofloxacin (*n* = 17).

Bier *et al.* (2018) reported that all isolates of *Salmonella* spp. from bovine carcasses were susceptible to ampicillin, gentamicin, ciprofloxacin, cefotaxime, chloramphenicol, and tetracycline.

Baptista *et al.* (2018) reported that of the 33 isolates of *Salmonella* spp. from chicken evaluated, 29 were susceptible to all tested antimicrobials and only 4 were resistant to at least one. The prevalence was deemed low compared to previous reports where at least 39% of isolates were resistant to at least one antimicrobial.

There are ongoing UK based projects looking at AMR in Brazilian poultry production (e.g. led by Quadram Institute, 2018-2019) which will shed further light on the situation.

14.4. References for Brazil

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15. Chile

15.1. Pork

15.1.1. Market overview

There are no recent GAIN reports for the Chilean market, and the last report on pork was published in 2008. The most recent update by Chile's 'La Oficina de Estudios y Políticas Agrarias' (ODEPA) states that pork production for Jan-Oct 2020 was 481,669 metric tonnes, which is a 20% increase from the same period in 2019. 85,619 metric tonnes of pork was imported in 2020 which is a 5% decrease from the previous year, but 258,871 metric tonnes were exported which is a 30% increase from the previous year (Brockway, 2020).

15.1.2. Production processes

No specific information was identified relating to pork production in Chile.

However, Supreme Decree No. 977/1996 (latest consolidated version 13 May 2020) approves the Food Sanitary Regulation, which sets out the health conditions that all production, import, processing, packaging, warehousing, distribution and sale of food products for human use shall observe, in order to protect the health and nutrition of the population and ensure the supply of healthy and safe food products (MINSAL, 1996).

15.1.2.1. Biosecurity

Very little was found on biosecurity measures implemented or required in Chile. There were trade press articles discussing the incoming threat from African Swine Fever, particularly from the Chinese market, but no official guidelines were found.

ChileCarne, a representative body for the meat industry in Chile, launched a biosecurity programme in 2019. The Biosecurity Program for Suppliers of Products Imported from China (BIO-REP) is designed to support the main importers of Chinese pork to screen their incoming shipments and implement a 60-day delay before marketing the imported products. Testing is performed at no extra cost to the importer (ChileCarne, 2019).

15.1.2.2. Transport and slaughter

General requirements for all livestock are established in Title I and Title XI of the Food Sanitary Regulation; General Technical Standard No. 62/ 2002 on medical veterinary inspection of animal slaughter and their meat.

Establishments for the slaughter of animals destined for human consumption are required to have been previously inspected and authorised by the sanitary authority for that purpose. In order to ensure compliance with Health and Sanitary requirements at slaughterhouses the Servicio Agrícola y Ganadero (Agricultural and Livestock Service) (SAG) – under the Ministry of Agriculture maintains official inspection teams (EIO), which are composed by both official veterinary inspector (MVO) and official technical inspectors (TIO) at all establishments. Slaughterhouses are required to keep a daily register of animal origin/provenance, carcasses, cuts, and also the by-products not destined to human consumption.

The meat inspected and declared proper for human consumption must bear the corresponding sanitary seal (stamp) of the slaughterhouse of origin. The seal constitutes the only sign indicating that the meat has been sanitary controlled in an authorised slaughterhouse and declared suitable for consumption. This stamping is under the MVO exclusive responsibility.

There are also particular requirements in relation to pork meat and trichinosis in Food Sanitary Regulation, Title XI, paragraph III; Decree No. 736/1947 on pigs creation, inspection and mitigation of trichinosis which must be followed as well as the requirements of the General Technical Standard no. 62/2002 (MINSAL, 2002).

Pork which is not slaughtered in legally authorised slaughterhouses, or which does not comply with the conditions indicated in above legislations, may not be sold. Also, it is forbidden for the cured meat and sausage factories to use pork in their food preparations which do not comply with the aforementioned requirements.

In the case of products for export it is required that all products must meet the sanitary requirements established by Chilean law and regional regulations for that specific meat product, which will be verified by SAG. As well as, for export of livestock products, it must

meet all national regulation, animal health and sanitary requirements of the importing country.

In addition, exporters are required to have an official certification (document) to trade products of animal origin (Export Animal Health Certificate (CZE, Certificado Zoosanitario de Exportación), in which the official veterinarian attests that what is being exported meets the requirements of the importing country.

However, in an audit undertaken by the European Commission (DG SANCO, 2013a) significant deficiencies were identified in the official controls and systems related to those animals slaughtered for the EU market.

15.1.2.3. Ante and post-mortem inspection

General Technical Standard No.62/2002 (MINSAL, 2002) is an extensive and detailed document which provide all procedures and guidelines on animal inspection ante, during and post-mortem, their carcasses, by/sub-products that result therefrom and the end-product.

All animals destined for slaughter (and human consumption) must be submitted to an ante-mortem inspection which is carried out by the MVO or third parties to whom they designate the responsibility. A post-mortem inspection is also conducted by the MVO or the TIO.

15.1.2.4. Chilling and other intervention steps

No information was identified relating to specific requirements for chilling (temperatures or times) nor for permitted washing agents.

The use of a Hazard Analysis and Critical Control Points system (HACCP) based approach in food establishments is adopted (MINSAL, 2015).

15.1.3. Microbiology

15.1.3.1. Microbiological criteria

Microbiological criteria are established in Food Sanitary Regulation, Title V, in which group no. 10 relates to meat and meat products, and 10.1 relates to raw meats (MINSAL, 1996) and in the General Technical Standard No. 62/2002 on medical veterinary inspection of animal slaughter and their meat.

Table 58: Chile, Pork – Microbiological criteria for raw meats

Organism/Group	*n*	*c*	*n*	*M*
Aerobic Mesophilic Count	5	3	10^5	10^7
Salmonella	5	1	Absence	-

n = number of samples to be tested from a batch/lot
m = criterion below which the batch is considered acceptable
M = criterion above which the result for any sample(s) would make the batch unacceptable
c = number of samples whose results can be between *m* and *M* for the batch to be acceptable

Chile has an equivalence determination for pork with USDA-FSIS for *Salmonella* (FSIS, 2009). This effectively means that Chile will apply the same criteria as that in the USA and opens the USA export market. This requires testing via accredited laboratories.

The USDA-FSIS criteria for hogs have an *n* = 55, *c* = 6. This is equivalent to a maximum allowable level of 8.7%. However, the USDA-FSIS evaluation document notes that Chile has implemented a zero-tolerance policy for raw products produced in official establishments.

In 2009, an EFSA report evaluated controls over the production of fresh meat from Chile, destined for export to the EU (DG Sanco, 2009). This does note that the microbiological criteria used in Chile (see table above) does not meet requirements in Commission Regulation (EC) No 2073/2005, the latter requiring weekly testing of 5 carcasses for *Salmonella*, aerobic colony count and *Enterobacteriaceae*. It appears that Chile put in an appropriate corrective action for this.

There are also specific requirements relating to *Trichinella* control (MINSAL, 2002; MINAGRI, 1947).

Livestock sampling techniques and laboratories follow ISO standards. Additionally, there is a standard on the detection of *Salmonella* in meat and meat products (INN, 1981).

15.1.3.2. Prevalence

15.1.3.2.1. *Salmonella*

Very little information could be found on *Salmonella* prevalence. A paper by Jansen *et al.* (2018) considered Chilean pork tested on import to the EU (through Germany). The paper reported that no *Salmonella* were found in 136 fresh boneless pork fillets that were tested in 2014-2015.

15.1.3.2.2. *Campylobacter*

No information could be found on the prevalence of *Campylobacter* on pork in Chile.

15.1.3.2.3. STEC

The only information identified on the prevalence of STEC on pork in Chile dated from a 1997 report (Borie *et al.*, 1997) when 120 pigs were tested and found that 68.3% contained EHEC (STEC).

15.1.3.2.4. *Trichinella*

In 2009, DG SANCO noted that at the time the method for *Trichinella* testing was not fully in line with that required in Regulation (EC) No 2075/2005 (the current EU legislation at the time). It appears that Chile put in an appropriate corrective action for this for pork destined for the EU.

Various reports suggest that *Trichinella* is endemic in Chile (Chaparro-Gutierrez *et al.*, 2018), however, this is predominantly in non-intensively reared pigs. Pigs raised under controlled conditions tend to be free of *Trichinella*.

15.2. Poultry

15.2.1. Market overview

The poultry market in Chile is dominated by a few (three) vertically integrated companies, one of which only produces for the domestic market (Bal & Gutiérrez, 2010). ODEPA reported that between Jan-Oct 2020, 639,996 metric tonnes of poultry were produced, the majority of which is broilers. This is a 1.4% rise on the same period in 2019. Chile imported 102,579 metric tonnes of poultry in 2020, this was a sharp decrease of 13.2% from 2019. They exported 142,564 metric tonnes which is a 5.3% rise on 2019 (Brockway, 2020).

15.2.2. Production processes

Little information was found on typical processing parameters in Chile.

15.2.2.1. Biosecurity

A DG SANCO report from 2013 states that “overall the system of official controls is capable of ensuring that the poultry meat exported to the EU meets most of the relevant standards”. Annual inspections of farms are conducted by an AV in order to retain their registration under the Animal Facilities Program under Official Certification (PABCO). AV are responsible for issuing a “report of origin” 72 hours before each flock is sent for slaughter. This contains food chain information in line with EU requirements including treatments, mortality rates and occurrence of disease (DG SANCO, 2013b).

15.2.2.2. Transport and slaughter

The General Technical Standard No.62/2002 is an extensive and detailed document which provides all procedures and guidelines on animal inspection ante, during and post-mortem, their carcasses, by/sub-products that result therefrom, end-product.

It is prohibited to slaughter animals destined for human consumption in establishments other than those previously inspected and authorised by the sanitary authority for that purpose. In order to ensure compliance with Health and Sanitary requirements at

slaughterhouses (assuring ultimately products are proper for consumption), the Agricultural and Livestock Service (SAG) has arranged to maintain, in all establishments, official inspection teams (EIO), which are composed by both official veterinary inspector (MVO) and official technical inspectors (TIO).

All animals destined to slaughter (and human consumption afterwards) must be submitted to an ante-mortem inspection which is carried out by the MVO or third parties to whom they designate the responsibility; a post-mortem inspection must be carried out by the MVO or the TIO.

Slaughterhouses must keep a daily register of animal origin/provenance, carcasses, cuts, and also the by-products not destined for human consumption. In addition, slaughterhouses must be equipped with all necessary instruments in order to actively detect *Trichinella* and other parasites. Commercialisation and trade of meat and meat products which contain pesticide residues, residues of veterinary drugs and additives, used in animal feed, that are above the tolerance limits set (by the Ministry of Health) is prohibited.

The meat inspected and declared proper for human consumption must bear the corresponding sanitary seal (stamp) of the slaughterhouse of origin. The seal constitutes the only sign indicating that the meat has been sanitary controlled in an authorised slaughterhouse and declared suitable for consumption. This stamping is exclusively under the MVO's responsibility.

15.2.2.3. Ante and post-mortem inspection

Checks on each flock are to be performed upon arrival at the slaughterhouse, including checking documents including "report of origin", visual inspection and autopsy on birds dead on arrival. If birds do not arrive at the slaughterhouse with a "report of origin" the meat is allowed to be processed but must be withheld from EU export until the document has been obtained (DG SANCO, 2013a).

OAs carry out post-mortem inspection under supervision from an OV. EU law requires the OV to carry out daily inspection of the carcass viscera and body cavities, and the OA can then declare fit for human consumption (Regulation (EC) No 853/2004). It was found in the 2013 audit that in some establishments the OV was not carrying out this daily

check and instead leaving to the OAs. It was also found on one occasion that some slaughterhouse staff would remove parts of the bird deemed abnormal and sometimes whole carcasses removed. This is not in line with EU requirements in Regulation (EC) No 854/2005 where all birds are to undergo post-mortem inspection and all external surfaces must be viewed during inspection (DG SANCO, 2013a).

All products must meet the sanitary requirements established by Chilean law and regional regulations for that specific meat product, which will be verified by SAG. As well as for export of livestock products, it must meet all national regulation, animal health and sanitary requirements of the importing country.

In addition, exporters are required to have an official certification (document) to trade products of animal origin, which is entitled Export Animal Health Certificate (CZE, Certificado Zoosanitario de Exportación), in which the official veterinarian attests that what is being exported meets the requirements of the importing country.

15.2.2.4. Chilling and other intervention steps

Limited to no knowledge was acquired about how Chile chill down poultry carcasses.

In relation to washes, specific antimicrobials and their concentration limits to be used in certain stages of the slaughtering process, and certain poultry meat parts (more specifically the carcasses and poultry offal) are approved according to Annex No. 2 of the General Technical Standard No. 117/2010 on poultry and poultry meat veterinary inspections (MINSAL, 2010). These include for example derivatives of chlorine, chlorine dioxide, various organic and peroxy acids.

15.2.3. Microbiology

15.2.3.1. Microbiological criteria

Microbiological criteria are established in Food Sanitary Regulation, Title V, in which group no. 10 relates to meat and meat products; and in the General Technical Standard No. 62/2002 on medical veterinary inspection of animal slaughter and their meat.

15.2.3.1.1. *Salmonella*

USDA-FSIS information (FSIS, 2009) indicates that Chile has a programme for sampling and analysis for *Salmonella* in meat and poultry products that is equivalent to that in the USA, and fully meets the USDA established criteria.

The USDA report also noted that laboratories used to do the testing were accredited/approved by the Government. Sampling of carcasses is done using the USDA whole bird rinse method. The methods used were the USDA-FSIS MLG 4A.01 and MLG 4.02 methods for detection of *Salmonella*.

The USDA quote a food safety measure with a performance standard that must be met. These standards are as follows:

Table 59: Chile, Poultry – Performance Standard

Product	Performance Standard (% positive for *Salmonella*)	n (number tested)	c (allowed number of failures)
Broilers	20	51	12
Ground chicken	44.6	53	26
Ground turkey	49.9	53	29

Although the USDA has published a performance standard their report, Chile have actually adopted a zero tolerance (i.e. no *Salmonella* detected) policy for exports produced in official establishments exporting to the USA

A Chilean Government Instruction (SAG, 2012), specifically covers *Salmonella* verification instructions for export of meats (including poultry) to Sweden. (This is reported to be done to comply with Commission Regulation (EC) No 1688/2005. This requires a zero tolerance policy (i.e. no *Salmonella* detected) for exports to Sweden.

The EC through DG SANCO also conducted an audit of the control systems covering production of poultry meat intended for export to the EU (DG SANCO, 2013a). This notes that the SAG in Chile is the competent authority (as defined by the EU) for official controls on poultry meat and products.

The audit noted that all poultry establishments that were visited had regular own-check sampling programmes for microbiological analysis. Five samples were taken from a batch of poultry meat preparations on a weekly basis (in line with EU requirements at the time) and analysed for at least *Salmonella* and *E. coli*. However, it was noted that the food safety criterion for fresh poultry meat (Commission Regulation (EC) No 2073/2005) was not (at the time) met (one sample per batch per week, not 5 samples).

Samples taken were neck skin and analysis were performed in ISO 17025 accredited laboratories. Methods used were not always ISO 6579, but evidence of method validation was noted.

The audit concluded that: “Overall, the system of official controls is capable of ensuring that the poultry meat exported to the EU meets most of the relevant standards”.

A subsequent audit however found that a number of recommendations in the previous audit had not been acted upon and concluded that:

“Due to the high prevalence of *Salmonella* spp. at farm and slaughterhouse level, the lack of effective measures, to date, to reduce that prevalence and the limited competent authorities’ verification of food business operators’ self-control actions, it cannot be ensured that exported poultry meat and products therefrom meet all the relevant EU requirements provided for in the model export health certificates”.

15.2.3.1.2. *Campylobacter*

Chile has undertaken a Risk Profile for *Campylobacter* in poultry meat (ACHIPIA, 2017). This gives details of the organism and its infective capacity to humans, comments on control measures and also on the prevalence of *Campylobacter* in Chilean poultry (see later). The document does note that at the time it was written the Chilean Sanitary Regulations of Food (Decree No. 977/96) does not establish microbiological criteria for *Campylobacter* spp. in meats of poultry or other food.

For poultry destined for export to the USA, Chile appears to have an official control programme (SAG, 2016). This appears to be specifically for compliance to the requirements of the USA.

This programme required testing of samples (whole bird rinse to be done for chickens, and neck skin samples to be done for turkey). Samples are sent to an accredited laboratory where presence absence testing is done using either the ISO 10272-1 or an ISO 146140 validated immunoassay method. Note this is for presence or absence testing not enumeration.

Decision criteria are based on a moving window of 60 consecutive samples (over 12 months) where acceptance criteria are:

Table 60: Chile, Poultry – *Campylobacter* acceptance levels

Species	Acceptance level (max positive samples)
Chicken	</= 50
Turkey	</= 38

Action plans in case of failures are detailed within the document.

Overall conclusions on microbiological criteria: it would seem that Chile generally notes the relevant criteria in the countries it wishes to export to, and then puts in place appropriate sampling, and testing to the relevant criteria.

15.2.3.2. Prevalence

15.2.3.2.1. *Salmonella*

Data on prevalence of *Salmonella* in Chilean poultry is difficult to obtain in published literature. Chile appear to match the requirements of countries/areas that they export to (see examples from USA, Europe & Sweden above).

There is limited data in the Ministry of Health Report (MINSAL, 2016) which gives national testing data from 2015.

Table 61: Chile, Poultry – *Salmonella* national testing data (2015)

Product	Number tested	Number positive	Percent
Poultry meat	177	5	2.82

Huepe *et al.* (2010) considered prevalence in chicken carcasses in southern Chile and found 5 out of 280 samples analysed were positive (1.8%).

15.2.3.2.2. *Campylobacter*

In Chile, during the period February 2014 to February 2015, a study was conducted to generate a baseline for *Campylobacter jejuni* / *coli* in carcasses of chickens and turkeys (noted in ACHIPIA, 2017). For this, 473 samples from 7 slaughterhouses were processed. According to the results 68.7% of the samples in chicken carcasses were positive for *C. jejuni* / *coli* and 56% in the case of turkey carcasses.

Table 62: Chile, Poultry – Carcass data re *Campylobacter*

Species	Number positive (%)	Number negative	Total tested
Chicken	206 (68.7%)	94	300
Turkey	97 (56%)	76	173
Total	303 (64.1%)	170	473

Note: All presence or absence testing, no enumerative data

Studies of poultry at retail level has indicated that *C. jejuni* has decreased in whole birds from 90% in 1982 to 37% in 1996 in frozen gutted chickens. The last study carried out on samples of frozen chickens in a plant processor described *C. jejuni* prevalence of 12%. This decrease is believed to be associated with hygiene measures taken by the producing companies in the management of the poultry slaughterhouses (Figueroa, 2006).

A publication by Figueroa *et al.* (2009) considered *Campylobacter* contamination of carcasses in the slaughterhouse. This calculated an overall contamination with *Campylobacter* of 54% (*n* = 338), although this varied depending on slaughterhouse (the range 36% to 72%).

During 2015, the National Program for Microbiological Food Surveillance of the Ministry of Health took 365 samples of raw poultry meat throughout the country, of which 163 (44.7%) were positive to *Campylobacter* spp. (MINSAL, 2016).

15.3. Antimicrobial resistance

In 2005, San Martín *et al.* noted that the Ministry of Agriculture of Chile was implementing a National Control Plan of Drug Residues in pigs, poultry and bovines, but that at that time there was no program for monitoring bacterial resistance, any restriction on the acquisition and use of these drugs. These authors noted that antimicrobials could be acquired and used in many cases without the supervision of a veterinarian.

In 2017, The Ministry of Health launched a National Plan Against Antimicrobial Resistance (MINSAL, 2017).

Rivera *et al.* (2011) reported that 11.8% of isolates of *Campylobacter* from poultry faeces were resistant to ciprofloxacin while none were resistant to erythromycin (*n* = 17).

A review published by Mateus *et al.* (2016) reviewed the significance of the food chain in antimicrobial resistance. This review found little information relating to AMR and poultry production in Chile. A paper by González-Hein *et al.* (2013) was the only one used in the review noting any data. It related to *Campylobacter jejuni* in chicken meat between 2006 and 2010 and reported that, of the 55 isolates obtained from chicken meat, 32 (58.2%) were resistant to ciprofloxacin and 1.8% were resistant to erythromycin.

Lapierre *et al.* (2016) reported that all isolates of *Campylobacter* isolates from retail pig meat were resistant to ciprofloxacin and tetracycline (*n* = 3). *Campylobacter* isolates from retail chicken meat were reported to be resistant to ciprofloxacin (36%), erythromycin (13%), and tetracycline (38%) (*n* = 3).

No other data were found for antimicrobial resistance in poultry or pork.

15.4. References for Chile

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16. Uruguay

16.1. Beef

16.1.1. Market overview

According to a GAIN report from 2019, Uruguay has around 44,000 cattle operations, most of which are small in size and family owned. Around 75% of cattle are grass fed, the rest are mostly grain fed. Six large companies slaughter around 70% of the country's total, with two large Brazilian companies running seven plants which cover 40% of the total number slaughtered annually (FAS, 2019).

Two decades ago, there were approximately 11 million heads of cattle in Uruguay. More than 80% of the livestock were British breeds (Hereford, Aberdeen Angus) (INAC, 2004).

16.1.2. Production processes

16.1.2.1. Biosecurity

A DG SANCO report from 2013 found that when visiting slaughterhouses there were some non-conformances around traceability of cattle. One issue raised was the lack of a system to cross-check the identities of cattle at both the holding of provenance and the slaughterhouse (DG SANCO, 2013). In a further audit in 2016, this was found to be improved and deemed acceptable for EU standards (DG Santé, 2016).

Beef is produced according to Good Manufacturing Practices (GMP), Standard Sanitation Operating procedures (SSOP) and Hazard Analysis and Critical Control Point HACCP) (INAC, 2015). The Ministry of Livestock, Agriculture and Fisheries (MGAP) and the National Meat Institute (INAC) are responsible for ensuring the fulfilment of these requirements.

16.1.2.2. Transport and slaughter

Slaughter can only occur in establishments registered under MGAP, previously authorised and (jointly) inspected by IVO (Official Veterinary Inspection), DIA and INAC.

Some other findings from the DG SANCO audit (2013) were that pressurised water was used to wash carcasses which could lead to cross contamination, and some carcasses and viscera were coming into contact with equipment. Some de-hiding was not performed correctly and led to faecal contamination particularly in the abdominal area (DG SANCO, 2013).

16.1.2.3. Ante and post-mortem inspection

Ante-mortem inspection must be carried out by the Official Veterinary Inspection team (IVO) which consists of a veterinary inspector and trained assistants from the Animal Industry Division (DIA). Prior to slaughter, the establishment must ensure that animals arrive at predetermined times, in the presence of the IVO team which also controls documentation accompanying the animals. The examination must be done as soon as the animals arrive at the establishment, and it may happen as many times as the IVO team so decide. This is followed by a last examination straight before slaughter. Post-mortem inspection must also be carried out by an IVO veterinary inspector. Cattle carcass-specific examination conditions and rules are set in Decree No. 369/1983 (Article 41). In cases where the veterinary inspector deems necessary, they can proceed to the withdrawal of samples for laboratory analysis. The control system in place requires the permanent presence of IVO team supervisors at slaughterhouses and cutting plants during working hours. They are in charge of supervising the performance of the official veterinarians at slaughterhouses and cutting plants. Private veterinarians who are trained externally can be accredited to certify the movements of live animals between holdings or to slaughterhouses.

16.1.2.4. Chilling and other intervention steps

Each establishment is required to establish a HACCP plan and undertake daily verification studies (FSIS, 2018). These are set at the national and regional level which often differ.

No hormones or antibiotics are allowed, and animal derivatives are not permitted for use in the animal feed.

Fresh meat must be chilled down to 7°C in deep muscle mass before transport, or if being transported within 50 km it is allowed to be at 10°C or lower (Decree No. 315/1994).

Lactic acid washes are permitted after final inspection of carcasses up to 2.5% concentration (DG Santé, 2016). The legislation does not make it clear if any other treatment processes are permitted. Chlorine is permitted in washing water up to 10ppm which is similar to potable water (DG Santé, 2016).

16.1.3. Microbiology

16.1.3.1. Microbiological criteria

All food related microbiological criteria and requirements in Uruguay are collected within the National Bromatological Regulation (Decree No. 315/1994). Those relating to meat and meat products are in Chapter 13.

This gives a general criterion for total mesophilic count of:

- Fresh and chilled meat: maximum: $1x10^{10}$ cfu/g
- Frozen meat maximum: $1x10^{7}$ cfu/g

Exceedance of these levels would make the meat “not fit for general consumption”.

No other general microbiological criteria were noted within this regulation.

A Programme for Pathogen Control and Reduction is in place whereby procedures and rules are established for *Salmonella*, *E. coli*, *Listeria monocytogenes* (INAC, 2015). These typically refer to compliance with requirements for the USA. The program is the responsibility of the DIA and is implemented through the Technical Departments (DT) and Slaughter Establishments. Samples are analysed by the official laboratory using the methods stipulated by FSIS (qualitative – absence/presence of *Salmonella*). If a non-conformity is notified, then the establishment is required to investigate and take corrective action. Any failing three consecutive assessments has the license withdrawn and are reported to the DIA to decide further action. However, no details of the outcome of these inspections were identified.

16.1.3.1.1. *Salmonella*

There is reference to *Salmonella* criteria in various USDA-FSIS country reports for Uruguay, over a number of years. In 2011, USDA Report (FSIS, 2011) on equivalence determination for Uruguay pathogen reduction program for *Salmonella* in fresh beef noted the following testing strategy was being used.

Table 63: Uruguay, Beef – USA Equivalence determination – Salmonella testing strategy performance standards

Product	% positive	Specified number of samples (sample set)	Maximum number of positives
Steers & heifers	1%	82	1
Cows & bulls	2.7%	58	2
Ground beef	7.5%	53	5

This was judged by USDA-FSIS to meet the relevant USDA requirements for import of meat into the USA in 2011.

16.1.3.1.2. *Campylobacter*

No criteria have been noted for *Campylobacter* in beef.

16.1.3.1.3. STEC

In 2015, the Ministry of Livestock, Agriculture and Fisheries (MGAP) published Resolution No. 245/015 approving two procedure manuals for beef – one for the control of *E. coli* O157 and a second one for the control of STEC (covering O157, O26, O45, O103, O111, O121 and O145) (this is the same as the USDA list of STEC) (MGAP, 2015). This Resolution was to introduce equivalency with the USDA/FSIS regulations on STEC and consisted of the N=60 sampling programme used in the USA on raw beef.

The testing requirement is for a weekly sample consisting of 60 pieces of meat is taken from the batch defined for the Official sampling program, on the dates established by the calendar sent by the Departamento Técnico (DT).

The official sample must come from the bovine meat (trimming and / or boneless meat that can be used to prepare minced meat) obtained from the animals of a lot, whose origin is from the same livestock establishment.

There is a zero-tolerance requirement for these 7 serogroups of STEC in the named beef products.

16.1.3.2. Prevalence

No national reports of surveys or audits were found. The majority of reports identified related to audits conducted by the USA authorities and/or against USA requirements.

16.1.3.2.1. *Salmonella*

Bosilevac *et al.* (2007) report on meat imported into the USA from Uruguay and note a prevalence of 0.39% (*n* = 256) for *Salmonella*.

The only other relevant data found was that from equivalence testing for USDA which requires no more than 1% positive in steers and heifers, 2.7% positive in cows and bulls and 7.5% positive in ground beef (see criteria section for full details).

16.1.3.2.2. *Campylobacter*

Bosilevac *et al.* (2007) report on meat imported into the USA from Uruguay and note a prevalence of 0.40% (*n* = 250) for *Campylobacter*.

16.1.3.2.3. STEC

A USDA-FSIS (2018) report from that considered the food safety systems governing the export of beef, lamb and pork to the USA from Uruguay, noted that the USA undertook 100% reinspection of meat products from March 2016 to January 2018. Of 171 million pounds weight of meat tested, the USDA rejected 30,000 pounds weight due to STEC O103 positives being detected.

Similarly, the most recent USDA-FSIS (2020) report noted that the USA undertook a 100% reinspection of meat products from Aug 2016 to July 2019, covering 284 million pounds weight of meat products. As a result of the reinspection of 441,000 pounds of raw beef products, it did not appear that any of the rejections were due to the presence of human pathogenic microorganisms.

Bosilevac *et al.* (2007) report on meat imported into the USA from Uruguay and note a prevalence of approximately 28% (*n* = 256) for non-O157 STEC.

16.2. Antimicrobial resistance

Food and Agriculture Organization (FAO) currently has an on-going project on “Containment of the Antimicrobial Resistance in terrestrial and aquatic food production systems, under the One Health approach in Latin America”. This project runs from March 2019 to November 2021 and looks at the target countries of Bolivia, Ecuador, Peru and Uruguay. The project aims to strengthen risk management based on scientific evidence, define a national strategy to contain AMR in livestock and aquaculture sectors, review legal frameworks and instruments that strengthen the management of the agri-food sector, and training in risk communication (FAO, 2019).

In 2018, the Government in Uruguay presented a national plan against antimicrobial resistance (Anon, 2018; MSP, 2018). The plan involves the Ministry of Public Health (controlling the use of drugs), the Ministry of Environment (water quality control), and the Ministry of Livestock, Agriculture and Fisheries (use of drugs in animals and chemicals in food manufacturing).

de los Santos *et al.* (2014) reported on resistance against penicillin in 4 *Staphylococcus aureus* isolates from cases of bovine subclinical mastitis in two Uruguayan dairy farms (*n* = 20). All isolates were susceptible to the other agents or agent combinations and none of the isolates showed resistance to more than one antimicrobial agent.

No other reports on the prevalence of antimicrobial resistance for Uruguay could be found.

16.3. References for Uruguay

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17. Australia

17.1. Beef

17.1.1. Market overview

Beef production extends over almost half of Australia, with about 47,000 cattle producers (Greenwood, 2018). Whilst there are a number of companies involved in red meat processing, JBS Australia is the largest contributor (MLA, 2019a).

The Australian beef industry had 25 million head of cattle in 2016-17, with a national beef breeding herd of 11.5 million head. Australian beef production includes pasture-based cow-calf systems, a backgrounding or grow-out period on pasture, and feedlot or pasture finishing. Feedlot finishing has assumed more importance in recent years to assure the eating quality of beef entering the relatively small Australian domestic market, and to enhance the supply of higher value beef for export markets (Greenwood, 2018).

Australia was the world′s third largest beef exporter in 2016 at around 13%, surpassed by Brazil at 24% (Greenwood, 2018). Japan was the largest importer of Australian beef, followed by the US, South Korea, China and Indonesia. Drought in Australia over several years has caused a lack of available pasture and high feed prices, which has affected beef export. As such Australia’s beef export is expected to drop sharply in 2020 (i.e. by 20%) due to the rebuilding of herds (and as such there will be a drop in female slaughter). Grain-fed beef is also likely to become a larger percentage of export (FAS, 2020).

17.1.2. Production processes

17.1.2.1. Biosecurity

A report by the Meat and Livestock Association (MLA) in 2018 details the number of establishments taking biosecurity measures. The survey showed that the vast majority of beef producers would shoot sick or injured livestock, but only 48% of producers have a quarantine procedure for introducing new livestock to a herd. Around 15% of producers did not have a procedure because they operate a closed herd system and bred their own replacements. Nearly all producers who had a quarantine plan separate new livestock

from the herd for a period of time, though this time varies across producers. 30% drip/drench stock on arrival and 16% vaccinate new stock. The figures collected on who vaccinates their livestock and against which diseases was varied depending on territory. Queensland, Western Australia and the Northern Territories were the only areas to have significant vaccinations against botulism, it may be that the other areas did not have as much risk of infection. It was more common across all regions to vaccine against clostridial diseases and younger calves were more commonly vaccinated than older animals. Endoparasiticides and ectoparasiticides were administered to 75% of the population via drenching (MLA, 2018a).

Animal Health Australia (AHA), an independent national animal health body, has an animal welfare standard and guidelines for cattle health. This prescribes that inspections on live cattle should be performed daily. There is guidance on how calves should be reared in their first stage of growth, this includes feeding requirements, disease control and required space and temperature conditions (AHA, 2016a). A biosecurity plan is required for new additions entering the facility (AHA, 2016b).

17.1.2.2. Slaughter and transport

Policy coordinator The Food Regulation Standing Committee (FRSC) produced a standard for hygienic production and transportation of meat which was published in 2007. This detailed how meat premises such as slaughterhouses and cutting plants should be maintained to keep an acceptable level of hygiene, however, a newer version than 2007 cannot be found. The document describes best practice for all parts of the production chain from slaughter to transporting of finished product.

For slaughter, the document describes methods of reducing cross-contamination from the dirty to clean parts of the slaughter process, including removing inedible parts of the carcass such as the digestive tract. Any carcasses which are suspected to be contaminated with inedible materials including chemical or biological, should be condemned or further examined by a meat safety inspector.

Meat should only be sourced from producers who are complying with programmes such as the National Residue Survey to ensure safe livestock is being sent for slaughter. Live animals suspected of disease or injury should be examined by a meat safety inspector

before slaughter. The identification of each animal is to be maintained and traceable until after post-mortem inspection (FRSC, 2007).

It is a well-established practice in Australia to use hormone growth promoters, however, these are not permitted in the EU. Therefore, establishments intended for export to this region do not accept cattle which are reared using these treatments (FSANZ, 2011; Gray, 2016).

17.1.2.3. Ante and post-mortem inspection

Meat safety inspectors employed by the government are responsible for ante and post-mortem inspection. Ante-mortem inspection must be completed within 24 hours of slaughter. Animals should be clean before inspection, or special measures taken during the process until removing the hide to reduce levels of contamination particularly from faeces. All relevant information should be provided for the meat safety inspectors including where the animals have come from, any suspected contact with sick animals and treatments they have been subjected to including results from any sampling, monitoring or testing. Animals are then defined as:

- passed for unconditional slaughter;
- passed for slaughter including certain conditions specified by the meat inspector;
- withheld from slaughter; or
- condemned.

Meat safety inspectors must be present during slaughter processes to examine the carcasses for further signs of disease or damage. The document specifies procedures for removing each part of the carcass particularly inedible ones. Faecal, urine, milk and other secretions are permitted to be removed before washing but only by a meat safety inspector, this also applies to exudate from any lesions which may contaminate other parts of the carcass.

Post-mortem inspections are conducted by meat safety inspectors. Based on this, meat is categorised into five classes (FRSC, 2007):

- passed for human consumption;
- retained for final disposition;

- unfit for human consumption and may be used for animal food;
- unfit for human consumption and may be used for pharmaceutical purposes; or
- condemned.

In 2011, the Australian Export Meat Inspection System (AEMIS) was created to make the system more flexible and cost-effective, transferring some of the cost to industry instead of absorbing the costs into government funding (AMPC, 2019). This was rejected by the EU and so establishments registered to export to EU are still required to use government inspectors for post-mortem inspection.

A report written by the Australian Meat Processors Corporation (AMPC) on AEMIS explains that there has been a shift in recent years in encouraging meat processors to use company and third-party inspectors called Australian Government Authorised Officers (AAOs) who would conduct post-mortem inspections instead of government employed inspectors. This system has not been completely adopted by industry, with only 50% of red meat processors using it. The largest producer in Australia, JBS, has moved back to the government system to continue exporting to the EU (AMPC, 2019).

The AEMIS scheme has been shown to improve efficiency on-plant and has also contributed to improvements in record keeping and results of inspection (AMPC, 2019). According to a DG Santé report from 2019, private meat inspectors cannot enforce sanctions on establishments as this can only be performed by the Department of Agriculture. Inspectors employed from third parties must be accredited under ISO 17020:2012 and improved by the Department of Agriculture (DG Santé, 2019).

17.1.2.4. Chilling and other intervention steps

Carcasses or parts of should be subjected to chilling within two hours of stunning. For carcasses, sides, quarters or major bone-in cuts, the surface of the meat should reach 7°C within 24 hours and have a continuous cooling curve. Cuts must be spaced appropriately to ensure condensation is not observed on the surface. Other carcass parts should reach 5°C within the 24-hour period. In Australia a Refrigeration Index (RI) is used to measure predicted growth of *E. coli* during chilling, guidance (FRSC, 2007) states that:

- an average refrigeration index should be no higher than 1.5;
- 80% of cuts should remain below an RI of 2.0;

- no cuts should have an RI higher than 2.5.

The refrigeration index can be calculated using an online/offline tool provided by the MLA (MLA, 2020a). This is not a technique routinely used in other countries and differs to the US model of chilling time based on weight, or the EU's lack of specific timings.

The MLA have published intervention summaries of different treatments used on meat. The use of chlorine in decontamination of red meat carcasses is not currently permitted above levels in potable water in Australia (10ppm). Organic acids are permitted for use on red meat carcasses but only as primals before further cutting procedures. Peroxyacetic acid and ozonated water are also approved for use which are not currently permitted in the EU. Rinse and Chill™ is permitted in Australia, a system where water and electrolytes are flushed through the vascular system to remove more blood from the carcass. This is also approved in the US but not in the EU (MLA, 2020b).

17.1.3. Microbiology

17.1.3.1. Microbiological criteria

Microbiological criteria for foods in Australia and New Zealand are given in the Australia New Zealand Food Standards Code, specifically in Schedule 27. However, it does not establish any limits for raw meats.

Food Standards Australia New Zealand publish a Compendium of Microbiological Criteria for Foods (FSANZ, 2018). However, this also does not specifically cover raw red meats.

There is an Australian Standard for the hygienic production and transportation of meat and meat products (FRSC, 2007), which is extremely comprehensive in setting out how animals are handled before & after slaughter but does not include microbiological criteria.

Thus, whilst microbiological criteria requirements are set for other food products, and there are also comprehensive requirements for the hygienic production and transportation of meat and meat products there are no specific microbiological criteria for meat.

17.1.3.2. Prevalence

17.1.3.2.1. *Salmonella*

The most recently information found has been MLABaseline survey of 2016 (MLA, 2017) that covered export meat. During this survey 5,452 sponge samples were taken from beef & veal producers throughout Australia.

Immediately after hide removal carcass *Salmonella* prevalence was 1.33% on beef and 3.75% on veal carcasses (*n* = 5,452). This was reduced at the end of processing before entry to chill store to 0.34% and 1.4% respectively (*n* = 5,452). All testing was undertaken in ISO 17025 accredited laboratories.

NSW Food Authority (2018) published data on the microbiological quality of beef, lamb and pork meat in New South Wales (NSW). Out of 54 samples of whole cuts, diced and minced beef and offal, no *Salmonella* were detected.

17.1.3.2.2. *Campylobacter*

The most recent *Campylobacter* prevalence data found was from 2019 (Walker *et al.*, 2019). This study considered levels in three Australian states (NSW, Queensland and Victoria). In beef offal, which may be considered a worst-case sample (kidney & liver), the overall prevalence of *Campylobacter* was 14% (n-216).

NSW Food Authority (2018) tested 138 samples of whole cuts, diced and minced beef and offal. *Campylobacter* was detected in 3 samples (2.2%) and in none of the 3 were levels noted as being >100/g.

17.1.3.2.3. STEC

In 2006, Barlow *et al.* reported on the prevalence of STEC in Australian ground beef and lamb cuts. Samples were collected over a 52-week period from 31 different outlets. 25 g portions were assayed for STEC. STEC were isolated from 46/285 (16%) ground beef samples. *E. coli* attaching and effacing gene (*eae*) were not found in any isolate. The STEC isolates comprised 18 serogroups but O157, O111 and O26 were not found. O174 and O91 were the most common serogroups isolated from beef. STEC were isolated from 111/275 (40%) lamb samples using a *stx* PCR screen. Interestingly STEC containing *eae* gene was not detected. It was reported that STEC of serotypes O157,

O111 and O26 (common enterohaemorrhagic *E. coli* serotypes) were not isolated. O128 and O91 the most common from lamb samples.

A survey in 2013 considered *E. coli* O157. Prevalence in cattle presenting at slaughter was noted as 4.9% in adult beef cattle, 10.5% in veal cattle, and 8.4% in young beef (*n* = 1,500 in all cases) (MLA, 2015).

One report published in 2011 indicated that in tests done on cattle faeces non-*E. coli* O157 STEC were very rarely found (MLA, 2011).

17.2. Lamb

17.2.1. Market overview

Australia's largest lamb/mutton export markets are the US, Middle East and China. New Zealand and Australia combined account for 70% of lamb trade around the world, sharing around 35% of this each. Lamb slaughter figures in Australia have fallen in the last few years due to the dry weather. In 2019, they dropped by 7% the lowest total since 2012. Western Australia is predicted to have less rainfall than other regions, with only small areas around the rest of the country expecting to exceed rainfall and therefore improve conditions for rearing sheep. Australia is considering changing the definition of lamb to move in-line with New Zealand standards, allowing them around an extra 30 days to finish lambs before slaughter. This may improve slaughter figures in the coming years (MLA, 2019b).

17.2.2. Production processes

17.2.2.1. Biosecurity

Sheep standards issued by Animal Health Australia advise that sheep should be inspected for health condition every day. Feed and water troughs should be regularly cleaned to reduce faecal and disease contamination. A biosecurity plan should be in place for new sheep entering the facility (AHA, 2016b).

17.2.2.2. Slaughter and transport

See 17.1.2.2.

17.2.2.3. Ante and post-mortem inspection

See 17.1.2.3.

17.2.2.4. Chilling and other intervention steps

See 17.1.2.4.

17.2.3. Microbiology

17.2.3.1. Microbiological criteria

See 17.1.3.1.

17.2.3.2. Prevalence

17.2.3.2.1. *Salmonella*

Phillips *et al.* (2013) reported on a baseline study on sheep meat undertaken in 2011. This noted *Salmonella* prevalence of 2% in leg (*n* = 613), 0.8% on shoulder (*n* = 613) and 3% in frozen boneless meat (*n* = 551).

NSW Food Authority (2018) tested a range of meat in Australia for *Campylobacter* and other pathogens, including *Salmonella*. This report noted that of 92 lamb (meat & offal) samples tested, one sample (lamb kidney) tested positive for *Salmonella* (1% prevalence).

17.2.3.2.2. *Campylobacter*

The most recent *Campylobacter* prevalence data found was from 2019 (Walker *et al.*, 2019). This considered levels in three Australian states (NSW, Queensland and Victoria). *Campylobacter* was tested in offal which may be considered a worst-case sample (kidney & liver) and overall prevalence in lamb offal was 38% (*n* = 206). It was noted that prevalence was significantly higher in fresh lamb offal (46%) that frozen (17%).

The report by NSW Food Authority (2018) considered prevalence in New South Wales (NSW). 180 samples of lamb meat and offal were tested. *Campylobacter* prevalence (presence in 25 g sample) was 19.4% for all lamb samples (Offal prevalence 55.9%). This report also gave some enumerative values, with 21.7% samples being at >10/g, and 1.2% at >100/g.

17.2.3.2.3. STEC

In 2006, Barlow *et al.* reported on STEC in beef and lamb cuts in Australia. STEC were isolated from 111/275 (40%) lamb samples using an *stx* PCR screen. Interestingly, STEC containing *eae* gene was not detected. It was reported that STEC of serotypes O157,

O111 and O26 (common enterohaemorrhagic *E. coli* serotypes) were not isolated. O128 and O91 were the most common from lamb samples.

MLA (2012) reported on a survey in 2012 that noted a prevalence of *E. coli* O157 in 0.3% lamb leg samples and 0.2% lamb shoulder samples (*n* = 613 in both cases).

17.3. Antimicrobial resistance

In 2020, the second National Antimicrobial Resistance Strategy was released aiming to minimise development and spread of antimicrobial resistance and to ensure continued availability of effective antimicrobials (Australian Government, 2019).

The Australian Pesticides and Veterinary Medicines Authority (APVMA) evaluates and registers antimicrobials for animal use in Australia. This is reported to involve a risk assessment, including the risk of antimicrobial resistance developing. Most antimicrobials used in animals must be prescribed by a veterinarian. Australia has not registered the following for use with animals: fluoroquinolones, colistin and fourth generation cephalosporins. APVMA is working to regulate antibiotic use in animals (APVMA, 2017).

In 2014, the APVMA released a report on the quantity of antimicrobial products sold for veterinary use in Australia (APVMA, 2014). This produced the following data:

Table 64: Australia – Total sales of veterinary antimicrobials by year*

Animal type	2005-06	2006-07	2007-08	2008-09	2009-10
Food animals	655.0	571.5	580.0	481.5	644.0
Non-food animals	9.7	10.9	12.0	10.6	17.2
Total	664.8	582.4	592.0	492.0	661.2

*(Tonnes of active constituent). By animal type as estimated (July 2005 to June 2010)

Of the total quantity of antimicrobials sold for therapeutic purposes for use in food animals, approximately 49% were used in poultry, 15% in cattle and sheep and 36% in pigs.

Approximately 30% of total sales (by weight) of antimicrobials used for therapeutic purposes in food animals consisted of the polypeptide called bacitracin. Macrolides and streptogramins contributed an average 24%. Tetracyclines made up the next largest class, accounting for an average 23% of total sales. The antimicrobial coccidiostats used to prevent coccidiosis disease in chickens comprised over half of total veterinary antimicrobials sales. Coccidiostats belong to classes of antimicrobials not used in

humans and are not considered to contribute to AMR risks in humans. Growth promotors comprised 4%–7% of the total antimicrobials sold for use in Australian food animals. From 2005 to 2010 an average of 35.3 tonnes of antimicrobials was sold as growth promotors, with quantities across these years ranging from 23.8 tonnes to 47.2 tonnes.

As highlighted in a written evidence by the Alliance to Save Our Antibiotics (UK Parliament, 2019) on the subject of UK-Australia trade negotiations, Australia has not published any information on its farm antibiotic use for any year after 2010, and there was no reduction in Australian farm antibiotic use between 2005 and 2010. Based on sales data for 2010, the authors provided an approximate estimate of the use of antibiotics in cattle and sheep (not broken down) at somewhere between 5 mg/PCU and 8 mg/PCU. These levels are low considering that the use in sheep in the UK is estimated to be about 11 mg/PCU and use in cattle at around 17-20 mg/PCU. In comparison, the use in US cattle was indicated as 161 mg/PCU. On the other hand, the use of antibiotics in Australian poultry (299 mg/PCU) was deemed 18 times higher than in the UK (16 mg/PCU) and the use in Australian pigs (293 mg/PCU) was over 2.6 times higher than in the UK (110 mg/PCU). It was also emphasised that in Australia there is only a voluntary industry ban in place on the use of antibiotics considered medically important as growth promoters, and that several antibiotics not currently used in humans are still permitted to be used as growth promoters. On the other hand, Australia has never licensed the use of the high-priority critically important fluoroquinolone antibiotics in farm animals unlike the UK.

Hillerton *et al.* (2017) estimated antimicrobial use in Australia in food animals, excluding horses, at 44 mg/PCU based on data from 2010. O'Neill (2015) ranked Australia as the fifth-lowest for antibiotic use in agriculture among the 29 countries examined at the time of the review.

Meat & Livestock Australia (MLA, 2018b) published a report highlighting antimicrobial resistances and its concerns.

Considering prevalence of AMR bacteria, studies undertaken by Barlow *et al.* (2015; 2017) considered organisms isolated from cattle. In the 2015 paper, *E. coli* and *Salmonella* were considered, and it was noted that greater than 92% of isolates were susceptible to all antimicrobials tested, whilst in *Salmonella* 91.5% of beef cattle isolates

and all dairy cattle and veal calve isolates were susceptible to all to all antimicrobials tested. In 2017, the authors reported on the AMR status of *Enterococcus* from cattle. The report noted that there were high levels of resistance to antimicrobials that are not critically or highly important to human medicine, with resistance to flavomycin (80.2%) and lincomycin (85.4-94.2%) being reported. Resistance to antibiotics considered critically or highly important to human medicine such as tigecycline, daptomycin, vancomycin and linezolid was not present in this study.

Specific data on sheep and lamb could not be found.

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18. New Zealand

18.1. Lamb

18.1.1. Market overview

New Zealand is one of the world's largest exporters of lamb/mutton, responsible for around 35% of global trade at 475,000 tonnes, the same amount as Australia. Its main export markets are China and then US, with smaller quantities being sent to Japan, Taiwan, Korea and Canada (MLA, 2019).

The number of sheep reared in New Zealand have stayed constant in the past few years at around 21 million despite falling steadily since 2012. The number of breeding ewes has fallen since then, which correlates with the rise in mutton slaughter in the past couple of years (BLNZ, 2019). There was a temporary rise in 2020 exports of lamb to the UK but the AHDB has attributed this to reduction trading to China due to the coronavirus pandemic shutting down Chinese ports. Lamb exports to the UK are expected to decrease (Riley, 2020).

18.1.2. Production processes

18.1.2.1. Biosecurity

Beef and Lamb New Zealand released on-farm biosecurity guidelines for drystock in 2019. These cover seven intervention points:

- livestock movements;
- animal health management;
- people and equipment;
- feed and water;
- pest control;
- animal waste and carcass management; and
- shared knowledge and understanding.

The guide encourages farmers to develop a biosecurity plan with a veterinarian to ensure all the key points are covered (BLNZ, 2019).

18.1.2.2. Transport and slaughter

The Ministry for Primary Industries (MPI) released a Red Meat Code of Practice in 2017 which details what is required in legislation for red meat producers. Chapter 5 of Code of Practice details the requirements for hygienic slaughter and dressing. The overarching message is that the food business operator is responsible for implementing control systems to ensure that microbiological contamination is limited using a risk-based approach. HACCP and Good Hygienic Practice (GHP) should be applied (MPI, 2017a).

Slaughter must be performed at a rate at which animals can be accepted for dressing. Slaughter must meet welfare requirements detailing the Animal Welfare (Commercial Slaughter) Code of Welfare (2018). Traceability between parts of the animal, or animals in the case of batch processing, must be maintained until post-mortem inspection is completed. The de-hiding and evisceration steps must be controlled to reduce cross contamination. Carcasses should be kept separate until after they have passed post-mortem inspection (MPI, 2017a).

18.1.2.3. Ante and post-mortem inspection

Chapter 7 of the Red Meat Code of Practice gives requirements for ante-mortem inspection for each red meat species (MPI, 2017a). The AM examination must include whether an animal is:

- a suspect animal (including reasons why);
- a TB reactor;
- on a chemical residue list;
- Johne's vaccinated;
- on a disease surveillance suspect list;
- subject to any other relevant issues described on the animal status declaration (ASD) form.

Chapter 6 of the Red Meat Code of Practice (CoP) gives extensive criteria for post-mortem inspection for each type of red meat. It focuses on each organ/area of the

carcass and gives directions for each one in processing. The CoP says that the operator must present all animal material for post-mortem inspection and no lesions may be removed before this stage. Animal Products Officers (APO) conduct examinations and deem carcasses fit or unfit for human consumption. Suspect animals must be presented to the APO and retained for further examination. If any tissue has been identified as suspect by the ante-mortem inspection this must be presented as well (MPI, 2017a).

Examination service providers are required to have a quality system in place approved by the MPI which can reliably deliver:

- performance targets;
- statistical process control (control charts etc.);
- ongoing examiner competency; and
- examination in a manner that minimises distribution of contamination.

This system must be documented as part of the risk management programme (MPI, 2017a).

18.1.2.4. Chilling and other interventions steps

Chapter 9 of the Red Meat Code of Practice supplies chilling requirements for fresh and frozen meat. All meat must be chilled below 7°C or frozen below -12°C before leaving a primary processing plant unless a specific food safety programme is in place to transport partially chilled/frozen meat for further processing. Similar to Australia, New Zealand can employ a technique called the Process Hygiene Index (PHI) which is a modelled numerical value which takes into account historical data on cooling rates and a mathematical model of predicted microbiological growth. Meat should be cooled to 7°C or lower at a rate that controls mesophilic microbiological growth in line with the PHI (MPI, 2017a).

When ageing meat in a chilled environment this should not take longer than six days from slaughter, and meat should achieve its final preservation temperature within eight days of slaughter. This does not apply to vacuum packed meat. If freezing is to be delayed longer than 4 days from slaughter, the meat should be chilled below 4°C. Spray chilling is permitted in NZ, under the conditions that the carcass does not increase in weight from

before this step and parts of the carcass are not trimmed to account for the addition of excess water (MPI, 2017a).

Schedule 18 of the Australia New Zealand Food Standards Code lists the permitted processing aids for meat and their concentration limits as in Table 65.

Table 65: New Zealand, Lamb – Permitted processing aids for meat

Substance	Technological purpose	Maximum permitted limit (mg/kg)
Cetyl alcohol	To coat meat carcasses and primal cuts to prevent desiccation	1.0
1-Hydroxyethylidene-1,1-diphosphonic acid	Metal sequestrant for anti-microbial agents	GMP*
Lactoperoxidase from bovine milk	Reduce or inhibit microbial growth on meat carcasses	GMP
Octanoic acid	Anti-microbial agent	GMP
Salmonella phage preparation	Reduce populations of *Salmonella*	GMP
Sodium chlorite	Anti-microbial agent	Limit of determination of chlorite, chlorate, chlorous acid and chlorine dioxide
Sodium thiocyanate	Reduce/inhibit bacterial population on meat	GMP

* Good Manufacturing Practice

18.1.3. Microbiology

18.1.3.1. Microbiological criteria

Microbiological criteria for foods in Australia and New Zealand are given in the Australia New Zealand Food Standards Code, specifically in Schedule 27. However, it does not establish any limits for raw meats.

Food Standards Australia New Zealand publish a Compendium of Microbiological Criteria for Foods (FSANZ, 2018). However, this also does not specifically cover raw red meats.

There is an Australian Standard for the hygienic production and transportation of meat and meat products (FRSC, 2007), which is extremely comprehensive in setting out how animals are handled before & after slaughter but does not include Microbiological criteria.

The Food Administration section of the Ministry of Health in New Zealand have produced a document on “Microbiological Reference Criteria for Food” (Anon, 1995). This document does not give regulated standards but guidelines on what may be expected. Section 5.19 of the document covers meat.

Table 66: New Zealand, Lamb – Guidelines, Microbiological reference criteria for chopped, minced or manufactured meat (uncooked)

Organism/group	*n*	*c*	*m*	*M*
Aerobic plate count /g	5	3	500,000	5,000,000
Campylobacter /10g	5	1	0	
C. perfringens /g	5	3	100	1,000
Coag +ve *Staphylococci* /g	5	2	100	1,000
Faecal coliform /g	5	3	100	1,000
Salmonella /25g	5	1	0	

Source: Anon, 1995

n = number of samples to be tested from a batch/lot

m = criterion below which the batch is considered acceptable

M = criterion above which the result for any sample(s) would make the batch unacceptable

c = number of samples whose results can be between *m* and *M* for the batch to be acceptable

18.1.3.2. Prevalence

18.1.3.2.1. *Salmonella*

A report by Wong *et al.* (2007a) gave information on a national survey of *Salmonella* in uncooked retail meats. Overall, 1,108 samples were tested of five different meat types (chicken, lamb, veal, beef and pork). The prevalence of *Salmonella* in lamb was reported to be 1.3% (*n* = 230 for lamb).

18.1.3.2.2. *Campylobacter*

A report by Wong *et al.* (2007b) provided information on a national survey of *Campylobacter* in uncooked meats (beef, veal, chicken, lamb, and pork). 1,011 samples were tested and the prevalence in lamb was 6.9%.

In 2005, a report (Cornelius *et al.*, 2005) considered the prevalence of *Campylobacter* in raw sheep's liver. 272 samples were tested and 1,780 (66.2%) were found to be positive.

A New Zealand Institute of Environmental Science and Research Risk Profile of *Campylobacter* in red meat (Lake *et al.*, 2007) gave no further information on *Campylobacter* prevalence in raw lamb.

The most up to date information available gives a prevalence rate of 33% (*n* = 120) for lamb, hogget and mutton (Rivas *et al.*, 2021).

18.1.3.2.3. STEC

The New Zealand Ministry for Primary Industries has been monitoring beef and veal meat for the presence of *E. coli* O157:H7 since 1998 (MPI, 2014). In the second quarter of 2012, the STEC testing programme for red meat was expanded to include six additional serotypes: O26, O45, O103, O111, O121, and O145. Sampling is conducted at meat processing plants that export part or all of their production, and results are reported to the National Microbiological Database (NMD) administered by the Ministry. These results are not publicly available.

A paper published in 2006 (Cookson *et al.*, 2006), reported on the prevalence of STEC in healthy cattle and sheep in the North Island of New Zealand. The method used was to isolate *E. coli*, from faecal swabs, then to examine isolates for *stx*1 and *stx*2 and *eae* gene. 65.9% of healthy sheep were STEC positive, only 27.3 % of sheep were *eae* positive (*n* = 132).

A survey of retail raw meats (minced or diced samples) was undertaken between 2003 and 2005 (Wong *et al.*, 2006). This tested 231 lamb/mutton samples for *E. coli* O157:H7. The prevalence of STEC was determined by PCR for *stx*1 and *stx*2 on an enrichment broth. The *stx*1*and stx*2 genes were found 34/231 lamb/mutton samples (14.7%).

18.2. Antimicrobial resistance

In 2017, the New Zealand Government set out their objectives for managing antimicrobials (MoH & MPI, 2017a). New Zealand Antimicrobial Resistance Action Plan was published later that year (MoH & MPI, 2017b). The plan provides for national surveillance of AMR and antimicrobial consumption and for strategies to ensure antimicrobials are used appropriately in animal health and agriculture. The New Zealand Ministry for Primary Industries (MPI) has published guidance on the prudent use of antimicrobials in relation to animals and plants (MPI, 2017b).

In New Zealand food animals, the most antibiotics are used in the poultry, pig and dairy industries (PwC, 2015). Antibiotics are used among New Zealand animals for therapeutic purposes and preventative purposes, however, since 2000 antibiotics are not prescribed for growth promotion (Manson *et al.*, 2004).

There is little specific data for AMR in lamb/sheep in New Zealand. A general review of literature on the presence of antimicrobial resistance in food Australia and New Zealand was published by Australian Government Department of Health (2018). The review identified no data on antimicrobial resistance in red meat animal pathogens, while the data on AMR in red meat animal commensals was not specific to sheep. Some limited data from 2004 was identified showing that 28 *Campylobacter* spp. isolates from sheep faeces (15 *C. jejuni* and 13 *C. coli*) and an additional 24 *C. jejuni* isolates from sheep offal were all susceptible to erythromycin, ciprofloxacin, nalidixic acid, and tetracycline. Also, out of 342 ovine isolates of *Salmonella* spp., 25% were not susceptible to streptomycin.

Hillerton *et al.* (2017) described the use of antimicrobials in New Zealand in 2012 and compared then to other countries (26 European countries, Australia, Canada, and the USA). These authors noted that the estimated usage of antimicrobials for food animals in New Zealand for 2012 was 9.38 mg/PCU, 11.46 mg/PCU for 2013, and 10.22 mg/PCU for 2014. Total sales of antimicrobials between 2005-2014 increased on average by 2.5% or 1.5 tonnes per year, whilst total animal biomass decreased by an estimated 4.3%. In the countries examined, the estimated usage of antimicrobials in food producing animals in 2012 varied from 3.8 to 341 mg/PCU. O'Neill (2015) ranked New Zealand as the third-

lowest for antibiotic use in agriculture among the 29 countries examined at the time of the review.

The latest report on the sales of antibiotics for 2018 indicates that absolute majority of antibiotics used in production animals were used for species other than sheep as only 0.17% of antibiotics sold were for sheep (MPI, 2020). The total quantity of antibiotics sold during 2018 amounted to 68,765 kg (4% less than in 2017). Between 2014 and 2018 the sales never fluctuated by more than 4% and essentially followed the trends in the size of the animal population.

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19. Botswana

19.1. Beef

19.1.1. Market overview

Botswana has a livestock population of about 2 million cattle, with around 400,000 keepers, 13,500 holdings of which 314 of these are EU compliant. This number of EU compliant farms has dropped from 787 in 2018 due to farmers unable to uphold requirements for export. In the last few years there have been large droughts which have had a significant effect on the bovine population, dramatically reducing the size and prevalence of herds. The country only has one establishment approved for the export of meat to the EU (DG Santé, 2020).

The country has an appreciable level of wildlife, particularly buffalo, which carry foot and mouth disease (FMD) without symptoms. Botswana has a veterinary cordon fence (VCF) running through the country separating the north and south. The southern regions are considered safe to export to the EU as they have FMD-free status without vaccination. The northern zones, particularly closer to the border with Zimbabwe and the VCF, still show cases of FMD and are unable to export (DG Santé, 2015).

19.1.2. Production processes

19.1.2.1. Biosecurity

Botswana has encountered problems in recent years relating to cross-border livestock theft with Zimbabwe, which has perpetuated FMD. Wild animals also come into contact with cattle. This risk has also been transferred to the Caprivi region of Namibia due to wild buffalo roaming between the two borders without control (Mogotsi, 2016).

A DG SANCO audit from 2013 found that two northern regions of Botswana did not have correct controls in place for FMD and therefore their ability to export to the EU was suspended. Since then the most recent DG Santé audit in 2015 found that appropriate controls have been implemented since the previous visit, allowing for export to the EU

from one of these regions. Only feedlot and fenced farms are permitted to export to the EU, other areas named ‘crushes’ are gathering points for cattle and less controlled in terms of biosecurity and animal management (DG SANCO, 2013a; DG Santé, 2015).

Establishments intending to export are required to follow the World Organisation for Animal Health (OIE) code for FMD, particularly chapter 8.8 which gives guidance on animal health measures required to control the disease (OIE, 2016). It was found that these guidelines were not fully adhered to in all regions of Botswana with the competent authority applying different rules than the ones specified in OIE Articles 8.8.8 and 8.8.22. In particular, there is an OIE requirement where only meat which has been matured and deboned can be moved from non FMD-free to FMD-free zones, but there is no official requirement for this scenario in Botswana (DG Santé, 2015).

19.1.2.2. Transport and slaughter

The Botswana Animal Identification System (BAITS) is used to trace animals in the country through the use of ear tags. This covers around 85% of the cattle population. Animals must be identified before the age of four months. In order to transport cattle to slaughterhouses or between EU-registered farms, a movement permit must be obtained from the area officer. This is only allowed in the same disease control zone throughout the country. The BAITS database is updated as animals move around, the farmers are not required to keep records of their movements (DG Santé, 2015).

Slaughter has been shown to be performed effectively and humanely during audits (DG Santé, 2020).

19.1.2.3. Ante and post-mortem inspection

Ante-mortem inspection is carried out daily by an OV, even when there is no slaughter. Any suspect animals are subject to clinical examination and further lab testing if required. Any non-compliance is reported to the Principle Veterinary Officer in the district of origin. Animals are checked for general health, signs of adverse health conditions, condition for slaughter as well as their zone brand which identifies which zone of the country they have been transported from. The OV or an assistant meat inspection (MI) will check the food chain information before authorising slaughter; this includes the condition that

animals have been kept in residence at a holding for 40 or 90 days slaughter depending on the rules in the zone (DG Santé, 2020).

Post-mortem inspection is carried out by authorised MIs employed by the Department of Veterinary Services (DVS) under the supervision of an OV. The OV is responsible for carrying out further examinations of suspect carcasses and offal and will take samples for laboratory testing if necessary. The OV will also enter findings into a database which will correlate AMI and PMI daily (DG Santé, 2020).

19.1.2.4. Chilling and other intervention steps

The single EU approved establishment has a standard operating procedure of recording a continuous temperature profile for each chiller. Meat must be deboned and chilled in a 2°C environment for the first 24 hours, with a target of achieving <7°C and a final pH of below 6 within 48 hours. Any carcasses which do not meet these criteria are segregated and traded outside the EU market (DG Santé, 2020).

No information could be found in both regulatory and processing areas for carcass washing, but if an establishment is permitted to export beef to the EU, they will only be allowed to use potable water, clean water, recycled hot water or lactic acid washes.

The Botswana Meat Council (BMC) has implemented a Hazard Analysis Critical Control Point (HACCP) system which conforms to the requirements of the South African National Global Standard (SANS) 10330:2007 and British Consortium (BRCGS) Global Standard for food safety (Issue 6, 2011) (BMC). Note however that the current edition of the BRCGS at the time of writing this report is version 8.

19.1.3. Microbiology

19.1.3.1. Microbiological criteria

No local microbiological criteria were identified relating to beef. An audit undertaken by DG SANCO (2013a) noted that the corrective action to be taken in case of positive results for *Salmonella* or when the aerobic colony count or *Enterobacteriaceae* exceed the maximum limit of acceptance was not fully in line with the requirements set out in Commission Regulation (EC) No 2073/2005. This suggests that Commission Regulation

(EC) No 2073/2005 criteria were known but not fully implemented. However, these criteria are only implemented for beef exported to the EU.

In a subsequent audit (DG Santé, 2020) the microbiological criteria laid down in Commission Regulation (EC) No 2073/2005 were reviewed in detail in the slaughterhouse visited. It was reported that examination of carcasses was carried out with the prescribed frequency (five samples per week by the FBO and once per month by the District Veterinary Office (DVO) and the results were satisfactory, realistic and trending, and presented in a comprehensive way.

19.1.3.2. Prevalence

19.1.3.2.1. *Salmonella*

In an audit by DG SANCO (2013b), it was noted that testing undertaken by the Botswana National Veterinary Laboratory (BNVL) in 2012 indicated that 103 out of 510 carcasses (20%) were positive for *Salmonella*. It was also noted that the results of the FBO laboratory indicated no *Salmonella* were detected over the same time period.

A paper by Samaxa *et al.* (2012) considered prevalence of *Salmonella* in raw sausages in stores in Botswana. They found a prevalence in beef sausages of 25.30%.

Table 67: Botswana, Beef (raw) – *Salmonella* prevalence (Gashe & Mpuchane, 2000)

Sample	Number	No positive	%
Kidney	58	3	5.2
Liver	46	5	10.9
Minced meat	55	11	20
Steak	52	3	5.8
Stew	48	2	4.2
Tripe	40	6	15
Wors	55	5	9
Total	354	35	9.9

19.1.3.2.2. *Campylobacter*

No information on the prevalence of *Campylobacter* in beef in Botswana could be found.

19.1.3.2.3. STEC

In 2005, Magwira *et al.* reported on the prevalence of *E. coli* O157 in 400 retail beef samples collected from 15 supermarkets and butchers, October 2002 – March 2003.

Table 68: Botswana, Beef products, retail – Prevalence of *E. coli* O157

Beef product	Number	Prevalence (%)
Beef cubes	134	5.22
Minced beef	133	3.76
Sausages	133	2.26

It should be noted that the method used would only recover *E. coli* O157 and that other STEC serogroups, if present, would not be detected. No information could be found on prevalence of STEC in Botswana.

19.2. Antimicrobial resistance

A National Residue Monitoring Plan is in place monitoring the use of antimicrobials in animals. Monitoring is undertaken by the Botswana National Veterinary Laboratory (DG Santé, 2020).

No data on the use of antibiotics in Botswana was found.

Magwira *et al.* (2005) reported that all 15 isolates of *E. coli* O157 isolated from beef cubes, beef sausages, and minced beef susceptible to ampicillin, gentamicin, and cotrimoxazole. However, 53% of the isolates showed resistance to cephalothin. Also, resistance to sulphatriad (33%), colistin sulphate (26%), and tetracycline (26%) was reported.

A paper by Mrema *et al.* (2006) found that all *Salmonella* isolates from raw minced meat, raw burger patties, and raw fresh sausages were resistant to sulfisoxazole.

Samaxa *et al.* (2012) reported that all 20 isolates of *Salmonella* spp. from raw beef sausages were resistant to four common aminoglycoside antibiotics: amikacin, cefuroxime, gentamicin, and tombramycin. One isolate demonstrated additional resistance to nitrofurantoin and trimethoprim-sulfamethoxazole, and one showed intermediate resistance to amoxicillin–clavulanic acid.

de Vries *et al.* (2018) found that *Campylobacter* strains in diarrhoeal patients (n = 20) were highly similar to those found in broiler hens (n = 70). Of the isolated strains, 52% tested positive for t*etO*, 47% for *gyrA*-T86I and 72% for $bla_{\text{OXA-61}}$. 27% were found to contain all three resistance genes.

19.3. References for Botswana

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20. Namibia

20.1. Beef

20.1.1. Market overview

Namibia has been supplying small quantities of chilled and frozen beef to the EU and especially to the UK, for many years (AHDB, 2016). In 2016, the EU signed an Economic Partnership Agreement (EPA) with the Southern African Development Community (SADC). Namibia is reported to be the largest supplier of the group which is reported to be in part due to its high animal health status and robust disease controls, especially in relation to FMD (as above) (AHDB, 2018).

Cattle production is important to Namibia with 60% of households having ownership of some cattle. Nevertheless, the cattle resources of Namibia are limited and only contribute to a small portion of the 5% that their agriculture contributes to the economy. This is due to limited availability of natural grazing and access to inputs (e.g. feed), restricting the scope for feedlot finishing. The costs are high and there is a slow slaughterhouse throughput. Production of beef from Namibia does however include commercial ranching. 90 per cent of its trade with the UK in 2015 was chilled product, mainly consisting of steak cuts destined for the foodservice sector (AHDB, 2016).

Namibia has also recently started exporting beef to the US, after many years of trade negotiations. The state-owned company (Meatco) was the first to export to this region. Most exports are to South Africa, but these have fallen in recent years mainly due to drought in South Africa forcing farmers to slaughter their cows and hence lowering demand for Namibian beef (FAS, 2020). There are only three slaughterhouses approved for beef export to the EU, and at the time of a 2020 audit around 8,500 farms were EU approved (DG Santé, 2020).

20.1.2. Production processes

20.1.2.1. Biosecurity

There is a separation of cattle farms in Namibia in the form of a border named the 'Red Line' or 'Veterinary Cordon Fence' (VCF). This was created in the late 1800s as a response to viral outbreaks of rinderpest and later on was used for foot-and-mouth disease (FMD), protecting farms in the south (Schneider, 2012). The types of farms in each region are quite different; farms in the north are less structured and more communal land, whereas those in the south are more commercially focused and perimeter controlled (BDO, 2020). The Caprivi region of Namibia is still classed as an infection zone with respect to FMD as many wild buffalo cross the border between Botswana and Namibia carrying risk to this area of the country. The Zambezi region has also had a recent outbreak in 2019 (Meatco, 2019). Meat produced in the north is not currently approved for overseas export, so all meat considered for EU/UK export originates from south of the fence (DG Santé, 2020).

The EU has established an agreement with Namibia that the territory exporting beef must have been free from FMD without any vaccinations for 12 months. Animals must also have remained in holdings where there is no FMD vaccination performed and for which no FMD case has been recorded in the previous 30 days. Animals must remain separate from FMD positive livestock and be processed in a slaughterhouse where no case has been identified in the last 30 days. Animals must be subjected to ante-mortem inspection, looking specifically for signs of FMD (DG SANCO, 2013a).

A DG SANCO audit from 2013 highlighted that there were some concerns that *Salmonella*-positive carcass samples were being found and adequate corrective actions were not being taken by the food business operator or the competent authority (Directorate of Veterinary Service, DVS). As there has been no follow up audit on this topic it is not clear whether the situation has improved (DG SANCO, 2013b).

A DG Santé audit of Namibia from 2020 found that the country's residue monitoring plan for bovine animals was largely appropriate for export to the EU. It was noted that some authorised medications were exempt from controls, such as hormone 17-beta oestradiol,

and therefore the competent authorities could not guarantee its absence in meat destined for export to the EU (DG Santé, 2020).

20.1.2.2. Transport and slaughter

All establishments are required to be registered and approved by DVS as meeting the required standards e.g. with respect to Sanitation Standard Operating Procedure (SSOP), HACCP system, sampling programmes, animal acceptance criteria, slaughtering/humane handling procedures, product recall/traceability, pest control, food safety programs and special export requirements. Establishments supplying meat for export need to meet certain requirements (Circular V19/2015). Only the slaughter of cattle born and bred south of the Veterinary Cordon Fence is permitted. In addition, the establishment is not permitted to receive raw materials from other establishments for further processing. The establishment is also required to have a procedure for traceability and recall.

It is also required for all premises that facilities are constructed hygienically e.g. in a way to prevent direct product contamination or creation of insanitary conditions, to ensure that product does not come into contact with floors or walls, and that the facility is maintained in good condition.

The SSOP also requires the adoption of procedures to prevent potential carcass contamination during each step of the process, including procedures to prevent carcass contamination during hide removal, direct contact between carcasses, and carcass contamination with gastrointestinal contents during evisceration.

Abattoirs are graded into three bands, and these are subject to different requirements in terms of auditing and inspections. Abattoirs are to be audited by ISO standard auditors appointed by the Meat Board of Namibia. A-class facilities are audited bi-annually, B-class annually and C-class prior to their initial registration and are also subject to spot inspections. Any findings are communicated to the abattoirs and non-conformances are reported to the appropriate regulatory bodies (Meat Board of Namibia, 2018a). The percentage split of abattoirs across the 3 bands was not found.

20.1.2.3. Ante and post-mortem inspection

Ante-mortem inspection is conducted by DVS in-plant inspection personnel assigned by DVS. The OC, with the assistance of the OA, conducts ante-mortem inspection on the day of slaughter and identifies any animals not fit for human consumption e.g. showing signs of FMD.

Post-mortem inspection is again conducted by DVS in-plant inspection personnel. Heads, viscera and carcasses are assessed to determine whether slaughter has been conducted according to DVS requirements. This is conducted carcass-by-carcass prior to carcass wash to ensure carcasses are free from pathological conditions or contamination.

A DG SANCO audit from 2013 found that ante-mortem inspection was generally acceptable but there were discrepancies between the number of animals slaughtered and inspected, with some not being inspected before slaughter. Live animals were also not accompanied with appropriate food chain information or equivalent. Post-mortem inspection was being carried out by auxiliary veterinary staff under supervision from an official veterinarian, and in one slaughterhouse visited there were only post-mortem inspection results for five out of ten days slaughtering (DG SANCO, 2013b).

A Hazard Analysis and Critical Control Point (HACCP) system will form the basis for food safety official controls at handling, processing and consumer level. Good Agricultural Practices (GAP) as applied internationally shall form the basis of food safety at production level.

20.1.2.4. Chilling and other intervention steps

Little to no information on required chilling parameters or carcass washing steps was identified. A Meat Board of Namibia Seal of Quality certification is available (Meat Board of Namibia, 2018b) and specific criteria have been laid out to ensure meat is safe and wholesome as part of the scheme. Meat should be chilled below 7°C or frozen below -12°C but acceptable times to achieve these temperatures are not specified.

Similarly, no information was identified on permitted washes for carcass washing. It is reported however that there is a zero tolerance CCP for the presence of faecal matter, ingesta and milk on the carcass. This is conducted by both the establishment’s

employees and DVS in-plant inspection prior to the final wash in the beef slaughter establishment.

The national residue plan is used to prevent and control the presence of residues of veterinary drugs and contaminants in the tissues of slaughtered animals intended for meat and meat products for human consumption. DVS in-plant inspection personnel are responsible to undertake random sampling of animals. Samples are tested at the official control laboratories.

If farmers wish to participate in quality assurance schemes such as Farm Assured Namibia (FAN) then the use of hormones or growth promoters is not permitted. An On-farm Drug and Treatment Register is required if treatments are to be used, and medicines are only to be used if prescribed by a veterinarian. Antibiotics are not to be used as a first-line treatment or used preventatively. There are restrictions on transport times and humane killing methods for injured livestock (Meat Board of Namibia, 2018c).

20.1.3. Microbiology

There are Government Microbiological Testing Programs whereby the DVS requires the establishment to devise and implement a sampling and testing program to verify the effectiveness of process hygiene controls.

Circular 24/2015 STEC Verification Program states that Shiga toxin-producing *E. coli* (STECs) are an adulterant for raw beef products intended for non-intact use and requires establishments to identify STECs as a biological hazard and have at least one Critical Control Point (CCP).

Certified establishments are required to develop a sampling and testing program for non-intact use and to analyse samples for STECs O157; H7; O26, O45, O103, O111, O121 and O145. DVS personnel review the results. If repeated results demonstrate loss of process control after corrective actions, a further investigation is conducted and reported to the authorities.

Similarly, there is also a National Microbiological sampling program to monitor for the presence of *Salmonella.*

Testing of official verification samples collected from products that are destined for export is conducted by the national government reference laboratory (CVL) under the authority of the Ministry of Agriculture, Water and Forestry (MAWF). Namibia's government laboratory was accredited in accordance with ISO 17025 accreditation standards in February 2013 by the South African Development Community Accreditation Service and the South African National Accreditation System.

No information was identified in national publications concerning the sampling techniques, sample number, frequency or test methods. An audit carried out in 2013 (DG SANCO, 2013b) found that *Salmonella* methodology was not comparable between factories, however the methodologies used were not detailed.

20.1.3.1. Microbiological criteria

Whilst there would appear to be microbiological testing programs in place at establishments, no details were identified of microbiological criteria in national legislation. Overall, it appears that Namibia applies the microbiological criteria required by the countries to which it exports.

The Central Competent Authority (CCA) is the Directorate of Veterinary Services working under the Ministry of Agriculture, Water and Forestry. According to a USDA Audit (FAS, 2020), generic *E. coli* testing is implemented at a rate of 1 test per 300 carcasses using statistical process control to monitor results (as noted in Circular V18/2007). It also implements a national microbiological sampling programme to monitor *Salmonella* prevalence with Circular V19/2008 adopting the USDA-FSIS pathogen reduction performance standards for *Salmonella* in raw meat. FAS (2020) also noted that the CCA provides instructions to its inspection personnel to verify an establishment's corrective measures when it does not meet the performance standards.

The CCA also requires that a US-certified establishment must implement a sampling programme for STEC (O157, O26, O45, O103, O111, O121, and O145) based on the USDA N=60 methodology for each lot of products (Circular V24/2015).

In 2013, an audit by DG SANCO covered the operation of control over production of fresh bovine & ovine meat, farmed & wild game meat destines for export to the EU (DG SANCO, 2013b). This report noted that all slaughterhouses carried out microbiological

analysis and trending on carcasses. It was however noted that in the slaughterhouses visited, insufficient action was taken if *Salmonella* test results were positive. Issues were also noted with *Enterobacteriaceae* and aerobic plate count testing and actions on high results (not consistent with Commission Regulation (EC) No 2073/2005).

20.1.3.2. Prevalence

Details of published national surveillance or monitoring reports were not found on the public pages of the ministries responsible for ensuring food safety (Ministry of Health and Social Services, Ministry of Industrialisation, Trade and SME Development and Ministry of Agriculture, Water and Forestry). The following refer to reports in the scientific literature, however, again few reports were identified.

20.1.3.2.1. *Salmonella*

A large study of *Salmonella* prevalence in beef in Namibia was reported in 2015 (Shilangale *et al.*, 2015). This involved 9,508 beef samples (meat cuts, carcass swabs and meat fluid) taken between 2008 and 2009.

Table 69: Namibia, Beef – *Salmonella* presence in beef samples

Sample type	Meat Cuts *n*=3,424	Carcass swabs *n*=1,688	Meat fluid *n*=4,396
Prevalence	0.5%	2.67%	0.34%

Source: Shilangale *et al.*, 2015

A report published as a part of a Master's Degree in the University of Namibia (Simasiku, 2016) tested 138 beef samples from retail & wholesale markets. *Salmonella* prevalence was reported to be 14%.

20.1.3.2.2. *Campylobacter*

No information was found on the prevalence of *Campylobacter.*

20.1.3.2.3. STEC

A study of non-O157 STEC in Namibian beef trim has been reported (Molini *et al.*, 2016). 771 samples were tested. Results indicated that 136 (17.6%) of samples were positive for Shiga toxin gene (*stx*1 and/or 2) and *eae* genes.

Further serogrouping indicated that out of the 136 STEC positives: 33 were O103, 9 were O26, 5 were O121, 3 were O145, and one was O45. Thirty-five samples were positive for more than one STEC serogroup. Note that O157 was not specifically tested at the serogroup level.

20.2. Antimicrobial resistance

While we are aware that Namibia was working on the national action plan with the help of WHO since 2017, we could not locate a finalised plan.

Burki (2018) reports that Namibia stopped the use of antibiotics as animal growth promoters in 1991. Shilangale *et al.* (2012) note that veterinary drugs can only be obtained on prescription. The evidence available implies the use of antibiotics in food related animals is well controlled.

Shilangale *et al.* (2016) reported on antimicrobial resistance patterns of *Salmonella* spp. from beef in Namibia. A total of 81 *Salmonella* isolates were obtained from 9,508 routine beef samples taken in 2008-2009. 21 of these (26%) isolates belonging to 15 different *Salmonella* serovars exhibited resistance to at least one antimicrobial while the rest of the isolates were susceptible to all 16 antimicrobials tested. Notably, 13 (16%) showed resistance to two or more. Out of 21 resistant strains, 19 were found to be resistant to sulfisoxazole (90%) and 11 were resistant to both sulfisoxazole and trimethoprim-sulfamethoxazole (52%). Lower levels of resistance were found to tetracycline, amoxicillin-clavulanic acid, cephalothin, and chloramphenicol.

These findings were considered to be consistent with studies conducted in the neighbouring Botswana where 100% of *Salmonella* isolates from sausages, minced meat, and burger patty were found to be resistant to sulfisoxazole and some of the isolates from raw beef sausages were resistant to trimethoprim-sulfamethoxazole. The paper suggested that the situation in Namibia was not as bad as in other countries in Africa where significant levels of resistance were found to ampicillin, nalidixic acid, streptomycin, tetracycline, chloramphenicol, or multiple antimicrobials. This was considered to be a result of strict control measures on the use of antimicrobials in both humans and animals in Namibia.

20.3. References for Namibia

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21. India

21.1. Beef

21.1.1. Market overview

Most beef produced in India comes from cattle and water buffalo (FAS, 2019). Unlike cow slaughter, there is no social taboo in killing buffalo for meat (APEDA, 2019a). Around a third of meat in India comes from buffalo, less than 10% of meat is for value added products, the rest is either consumed fresh in India or exported fresh frozen.

Major export markets (2018-2019) include United Arab Emirates, Myanmar, Qatar, Maldives and Bhutan although buffalo meat is also exported to the United Kingdom. The main state (2018-2019) producing buffalo meat is Uttar Pradesh (600,000 tonnes) (APEDA, 2019b; Landes *et al.*, 2016).

21.1.2. Production processes

21.1.2.1. Biosecurity

Food business operators are required to have biosecurity plans in order to be export approved by Indian authorities (APEDA, 2020). Little or no information was found detailing the measures required.

In general, all food businesses are required to have a documented Food Safety Management Plan (FSMP) based on Hazard Analysis and Critical Control Point (HACCP). This is applicable to all FBOs from farm-to-fork. The FSMP is based on the implementation of Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) (FSSAI, 2019).

21.1.2.2. Transport and slaughter

There used to be many municipal slaughterhouses, many of which were unregistered, which would process meat for both domestic and export. In addition to this there are export-orientated slaughterhouses which hold much higher standards with HACCP and

ISO certification being mandatory (APEDA, 2020). In 2017, all unregistered slaughterhouses were ordered to close, causing a disruption in supply. As a result, the number of stray cattle rose due to farmers not wanting to rear unproductive cattle and there was a ban on their transport or sale (FAS, 2019). In the most recent livestock census, there has been a decline in stray cattle in the past two years (DAHD, 2019). The Uttar Pradesh region holds most of the export-orientated facilities as well as the largest share of the buffalo herd (Landes *et al.*, 2016).

Bovines are to be stunned by a captive bolt rendering them unconscious before shackling (Meat Food Products Order, 1973).

21.1.2.3. Ante and post-mortem inspection

Meat Food Products Inspectors carry out ante and post-mortem inspections; these are official veterinarians employed by APEDA. Indian legislation details inspection requirements in Section 22 of Schedule 3 of the Meat Food Products Order, 1973. All animals are to be suitably rested before slaughter and ante-mortem inspection to be performed in good time before slaughter. Suspect animals are to be kept separate for further examination by a Meat Food Products Inspector, and if deemed unsuitable for human consumption cannot enter the slaughter process. If an animal is declared suspect but does not show signs that the whole carcass is unacceptable the animal may enter the slaughter process only after all healthy animals and provided it is inspected by a Meat Food Products Inspector post-mortem. The legislation provides the characteristics which inspectors should look for, including signs of maltreatment or deformities.

For post-mortem inspection, all carcasses and viscera must be identified until after inspection, in order to allow for traceability in the event of any meat being condemned. Slightly bruised carcasses may be allowed to proceed through the production process and damaged parts removed after chilling if necessary. Post-mortem inspection should cover both the carcass and viscera and be performed by a Meat Food Products Inspector.

All establishments exporting product are required to be registered and inspections are conducted annually.

Food Safety and Standards (Food Safety Auditing) Regulations, 2018, introduced audits of Food Business Operators through private recognised auditing agencies (FSSAI, 2020). Thus, those establishments receiving satisfactory audits via the private recognised auditing agencies will lead to less frequent regulatory inspections by Central or State Licensing Authority except the regulatory sampling.

21.1.2.4. Chilling and other intervention steps

The Red Meat Manual provided by APEDA advises that carcasses must be chilled down to a safe temperature (not specified) within 24 hours, with a final meat pH of around 5.7~~6~~ (APEDA, 2020). The 3rd edition of this manual was published in 2020 and no specific guidance can be found within Indian legislation to confirm this. However, this time is reasonable best practice for bovine carcasses.

Antimicrobials permitted in washing or chilling are not specified.

21.1.3. Microbiology

21.1.3.1. Microbiological criteria

Microbiological criteria for foods in India are all detailed in the Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011. All microbiological criteria are in Table 5 of the Regulation (the references to Tables are those in the Regulations):

- Table 5A: Microbiological Standards for Meat and Meat Products – Process Hygiene Criteria
    - Aerobic Plate Count
    - Yeast and mould count
    - *Escherichia coli*
    - *Staphylococcus aureus* (Coagulase +ve)
- Table 5B: Microbiological Standards for Meat & Meat Products – Food Safety Criteria
    - *Salmonella*
    - *Listeria monocytogenes*
    - Sulphite reducing *Clostridia*

- *Clostridium botulinum*
- *Campylobacter* spp.

The sampling plan, limits and methods to be used are specified.

Requirements are given for various meat products.

21.1.3.2. Prevalence

Enforcement activities are undertaken in India and there are reports of these by individual states. Whilst these reports are not limited to just red meat, they do provide an indication of the food safety activities.

In Uttar Pradesh (2017-2018), where most buffalo processing takes place, the following activities were reported:

Table 70: India, Beef – Enforcement activities in the area of Uttar Pradesh, India (2017-2018)

Activity	Number
Number of state laboratories	5
Number of food samples collected	23,576
Number of food samples analysed	19,063
Number of food samples found adulterated, unsafe, substandard, or misbranded	8,375
Number of cases launched against FBOs: • Criminal • Civil	 102 7,232
Number of convictions and penalties against FBOs: • Convictions • Penalties	 3,237 4,219

Source: FSSAI Fact Sheets

Nevertheless, no nationally collected data could be found. There are some papers giving details of small local surveillance studies that have been undertaken. The absence of reports of larger coordinated studies across India hampers any good interpretation of the results.

21.1.3.2.1. *Salmonella*

In 2003, Bajaj *et al.* looked at the incidence of *Salmonella* in meats. They report an incidence of 56% in beef (*n* =< 266).

In 2014, Kumar *et al.* studied meat from slaughterhouses and retail meat shops in Hyderabad. 50 samples of beef were tested, and no *Salmonella* were detected.

A paper by Kalambhe *et al.* (2016) reported on *Salmonella* in slaughtered animals in the Nagpur region of central India. The paper reports on testing 50 beef samples and finding three positives for *Salmonella* (6%).

21.1.3.2.2. *Campylobacter*

No information could be found on prevalence of *Campylobacter* on/in bovine meat in India.

21.1.3.2.3. STEC

In 2002, Khan *et al.* reported on the prevalence of non-O157 STEC in Calcutta. Their report states that 50% of raw beef samples were positive (*n* = 111). However, the method used noted that PCR for *stx*1 and *stx*2 was used. It is not known if the authors confirmed that these were contained within *E. coli,* so this may be an over estimation. However, simply the high prevalence of the 2 toxin genes is of note.

In 2008, Dhanashree & Mallya reported on prevalence of STEC in meat (beef) samples in Mangalore. They tested 103 bovine samples using a method which isolated *E. coli*, then tested for the presence of *eae* and *stx* toxin genes. Results indicated that 80 beef meat samples contained *E. coli,* 40 of these were positive for the *eae* gene, but only one of these was positive for *stx* genes (*stx*1 and 2). This would indicate a low prevalence of 1% STEC in this study (*n* = 103).

Islam *et al.* (2008) quote Indian STEC data from other authors and note that STEC O157 has been isolated in India from foods of cattle origin, namely, raw minced beef samples (9%; *n* = 22), beef surface swabs (3.7%; *n* = 27).

21.2. Antimicrobial resistance

In 2017, India's National Action Plan for Antimicrobial Resistance was released by the Union Ministry of Health and Family Welfare (MoHFW, 2017). The objectives include improving awareness, enhancing surveillance measures, strengthening infection prevention and control, research and development, promoting investments, and collaborative activities to control antimicrobial resistance. On the basis of the National Action Plan, various states have begun the process of initiating their State Action Plans.

Walia *et al.* (2019) noted that in 2015 the Food Safety and Standards Authority of India (FSSAI, 2015) issued a draft order aimed at limiting the use of antibiotics in meat and meat products, but that it was still not implemented. They also noted that in the absence of any uniform policy about the antibiotics usage in animals in India, prophylactic use of antibiotic in poultry production and in livestock is common. These authors have also noted that colistin is widely used as a growth promoter in the production of food animals in India (this is a last resort antibiotic for humans in cases of carbapenem-resistant infection).

A review by Ranjalkar & Chandy (2019) also highlighted slow implementation of the National Action Plan so far and the fact that India was the largest consumer of antibiotics for human health (not per capita though). Taneja & Sharma (2019) noted that 76% of the overall increase in global antibiotic consumption between 2000 and 2010 was attributable to BRICS countries which includes India. In terms of antimicrobials used in food animals, India accounted for 3% of the global consumption in 2010 and was the fourth highest in the world, behind China (23%), the United States (13%), and Brazil (9%) (MoHFW, 2017).

Gandra *et al.* (2017) undertook a scoping report of antimicrobial resistance in India. This report aimed to summarise the current situation of antimicrobial resistance in India with a focus on antibacterial resistance, and to identify the current research gaps to determine future research priorities in India. For cattle, the data reported on antimicrobial resistance was limited to milk samples, mostly with mastitis. All isolates of *E. coli* from milk were found to be resistant to ampicillin, some were also resistant to amoxicillin-clavulanic acid, enrofloxacin, ceftriaxone, streptomycin, oxytetracycline, co-trimoxazole, or

chloramphenicol. Some *S. aureus* isolates from cow's milk were found to be resistant to penicillin, streptomycin, erythromycin, tetracycline, and vancomycin.

Shekh *et al.* (2013) reported resistance in *E. coli* isolates from buffalo meat to enrofloxacin (78%) and tetracycline (78%) (*n* = 9) while Khan *et al.* (2018) reported for *E. coli* STEC isolates from raw beef resistance to ampicillin (66.6%) and nalidixic acid (71.7%) (*n* = 22).

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Annex 1. European microbiological criteria – food safety and process hygiene

Members of the European Union and those countries wishing to export to the EU are required to meet the requirement of Commission Regulation (EC) No 2073/2005. This lays down the food safety criteria for relevant foodborne bacteria and their toxins. These differ slightly for different meats. Regulation also details the sampling rules and provides guidelines for sampling and sampling frequencies for carcasses, minced meat, meat preparations, mechanically separated meat and fresh poultry meat. Annex I of this Regulation separates the criteria into those relating to:

- Food safety (detailed in Chapter 1 of Annex I), and
- Process hygiene (listed in Chapter 2 of Annex I).

Actions to be taken if the criteria are breached differ for these two areas:

- Food safety criteria – unsatisfactory result requires the product or batch of foodstuffs to be withdrawn or recalled in accordance with Article 19 of Regulation (EC) No 178/2002. However, products placed on the market, which are not yet at retail level and which do not fulfil the food safety criteria, may be submitted to further processing by a treatment eliminating the hazard in question. This treatment may only be carried out by food business operators other than those at retail level.
- Process hygiene criteria – when these are exceeded, then individual actions are noted for each food category of Annex I Chapter 2. These tend to be centred on reviewing and improving hygiene or reviewing processes. They do not necessarily require withdrawal or recall.

Summaries of the microbiological criteria from Annex I of Commission Regulation (EC) No 2073/2005 relating to different meats are given in the Tables Table 71 to Table 75.

A1.1 Poultry

Table 71: EU, Poultry – Food safety criteria

Food category	Micro-organism	Sampling: *n*	Sampling: *c*	Limits: *m*	Limits: *M*	Test method	Stage where applies
1.5 Minced meat and meat preparations made from poultry meat intended to be eaten cooked	*Salmonella*	5	0	Not detected in 25 g		EN ISO 6579	Products placed on the market during the shelf-life
1.9 Meat products made from poultry meat intended to be eaten cooked	*Salmonella*	5	0	Not detected in 25 g		EN ISO 6579	Products placed on the market during the shelf-life
1.28 Fresh poultry meat	*Salmonella* Typhimurium *Salmonella* Enteritidis	5	0	Not detected in 25 g		EN ISO 6579-1 (for detection) White-Kauffmann-Le Minor scheme (for serotyping)	Products placed on the market during their shelf-life

Table 72: EU, Poultry – Process hygiene criteria

Food category	Micro-organism	Sampling: *n*	Sampling: *c*	Limits: *m*	Limits: *M*	Test method	Stage where applies
2.1.5 Poultry carcases of broilers and turkeys	*Salmonella* spp.	50	5	Not detected in 25 g of a pooled sample of neck skin		EN ISO 6579	Carcases after chilling
2.1.9 Carcases of broilers	*Campylobacter*	50	15* 10**	≤1,000 cfu/g		EN ISO 10272-2	Carcases after chilling

* From 1/1/2020

** From 1/1/2025

Key:
n = total number of samples to be tested
m = maximum level (results below this are within criteria)
M = maximum level allowed (results above this breach criteria)
c = allowable number of marginal results (number of results that criteria allow to be between *m* and *M*)

A1.2. Beef, lamb, and pork

It is important to note that European food safety criteria for beef, lamb, and pork are based on *Salmonella* and *Listeria monocytogenes* (the latter for ready-to-eat beef, lamb, and pork only). There are no criteria for STEC or *Campylobacter*. Indeed, paragraph 14 of Commission Regulation (EC) No 2073/2005 specifically notes that the Scientific Committee on Veterinary Measures relating to Public Health (SCVPH) considered that applying an end product standard for VTEC (STEC) was unlikely to deliver meaningful reductions in risk to consumers. It did note that the following categories were ones in which VTEC represented a hazard to public health: raw or undercooked beef, possibly meat from other ruminants, minced meat and fermented beef.

There is no consideration of *Campylobacter* as a hazard in beef, lamb, or pork products.

A summary of the food safety microbiological criteria relating to red meat (beef, lamb and pork) from Commission Regulation (EC) No 2073/2005 is given in table below. *Listeria* criteria (1.1, 1.2, and 1.3 are included as they will apply to any ready-to-eat beef, lamb, or pork).

Table 73: EU, Beef, Lamb, and Pork – Food safety criteria

Food category	Micro-organism	Sampling: *n*	Sampling: *c*	Limits: *m*	Limits: *M*	Test method	Stage where applies
1.1 Ready-to-eat foods intended for infants and ready-to-eat foods for special medical purposes	*Listeria monocyto-genes*	10	0	Not detected in 25 g	Not detected in 25 g	EN ISO 11290-1	Products placed on the market during their shelf-life
1.2 Ready-to-eat foods able to support the growth of *L. monocytogenes*, other than those intended for infants and for special medical purposes	*Listeria monocyto-genes*	5	0	100 cfu/g	Not detected in 25 g	EN ISO 11290-2	Products placed on the market during their shelf-life
	Listeria monocyto-genes	5	0	100 cfu/g	Not detected in 25 g	EN ISO 11290-1	Before the food has left the immediate control of the food business operator, who has produced it
1.3 Ready-to-eat foods unable to support the growth of *L. monocytogenes*, other than those intended for infants and for special medical purposes	*Listeria monocyto-genes*	5	0	100 cfu/g		EN ISO 11290-2	Products placed on the market during their shelf-life
1.4 Minced meat and meat preparations intended to be eaten raw	*Salmonella*	5	0	Not detected in 25 g		EN ISO 6579-1	Products placed on the market during their shelf-life
1.6 Minced meat and meat preparations made from other species than poultry intended to be eaten cooked	*Salmonella*	5	0	Not detected in 10 g		EN ISO 6579-1	Products placed on the market during their shelf-life

Food category	Micro-organism	Sampling: *n*	Sampling: *c*	Limits: *m*	Limits: *M*	Test method	Stage where applies
1.7 Mechanically separated meat (MSM)	*Salmonella*	5	0	Not detected in 10 g		EN ISO 6579-1	Products placed on the market during their shelf-life
1.8 Meat products intended to be eaten raw, excluding products where the manufacturing process or the composition of the product will eliminate the *Salmonella* risk	*Salmonella*	5	0	Not detected in 25 g		EN ISO 6579-1	Products placed on the market during their shelf-life

Key:
n = total number of samples to be tested
m = maximum level (results below this are within criteria)
M = maximum level allowed (results above this breach criteria)
c = allowable number of marginal results (number of results that criteria allow to be between *m* and *M*)

A1.2.1. Beef and lamb – process hygiene requirements

Process hygiene microbiological criteria for beef and lamb from Commission Regulation (EC) No 2073/2005 are summarised in the table below.

Table 74: EU, Beef and Lamb – Process hygiene criteria

Food category	Micro-organisms	Sampling: n	Sampling: n	Limits: c	Limits: m	Limits: M	Test method	Stage where applies	Action in case of unsatisfactory results
2.1.1 Carcases of cattle, sheep, goats and horses	Aerobic colony count			3,5 log cfu/cm^2 daily mean log	5,0 log cfu/cm^2 daily mean log	5,0 log cfu/cm^2 daily mean log	EN ISO 4833-1	Carcases after dressing but before chilling	Improvements in slaughter hygiene and review of process controls
2.1.1 Carcases of cattle, sheep, goats and horses	*Enterobacte-riaceae*			1,5 log cfu/cm^2 daily mean log	2,5 log cfu/cm^2 daily mean log	2,5 log cfu/cm^2 daily mean log	EN ISO 21528-2	Carcases after dressing but before chilling	Improvements in slaughter hygiene and review of process controls

2.1.3 Carcases of cattle, sheep, goats and horses	*Salmonella*	50	2	Not detected in the area tested per carcase	Not detected in the area tested	Not detected in the area tested	EN ISO 6579-1	Carcases after dressing but before chilling	Improvements in slaughter hygiene, review of process controls and of origin of animals
2.1.6 Minced meat	Aerobic colony count	5	2	5×10^5 cfu/g	5×10^6 cfu/g	5×10^6 cfu/g	EN ISO 4833-1	End of the manufacturing process	Improvements in production hygiene and improvements in selection and/or origin of raw materials
2.1.6 Minced meat	*E. coli*	5	2	50 cfu/g	500 cfu/g	500 cfu/g	ISO 16649-1 or 2	End of the manufacturing process	Improvements in production hygiene

									and improvements in selection and/or origin of raw materials
2.1.7 Mechanically separated meat (MSM)	Aerobic colony count	5	2	5×10^5 cfu/g	5×10^6 cfu/g	5×10^6 cfu/g	EN ISO 4833-1	End of the manufacturing process	Improvements in production hygiene and improvements in selection and/or origin of raw materials
2.1.7 Mechanically separated meat (MSM)	*E. coli*	5	2	50 cfu/g	500 cfu/g	500 cfu/g	ISO 16649-1 or 2	End of the manufacturing process	Improvements in production hygiene and improveme

									nts in selection and/or origin of raw materials
2.1.8 Meat preparations	*E. coli*	5	2	500 cfu/g or cm^2	5,000 cfu/g or cm^2	5,000 cfu/g or cm^2	ISO 16649-1 or 2	End of the manufacturing process	Improvements in production hygiene and improvements in selection and/or origin of raw materials

Key:
n = total number of samples to be tested
m = maximum level (results below this are within criteria)
M = maximum level allowed (results above this breach criteria)
c = allowable number of marginal results (number of results that criteria allow to be between *m* and *M*)

A1.2.2. Pork – process hygiene requirements

The process hygiene requirements for pork differ from those of beef and lamb and are summarised below.

Table 75: EU, Pork – Process hygiene criteria

Food category	Micro-organisms	Sampling		Limits		Test method	Stage where applies	Action in case of unsatisfactory results
		n	***c***	m	***M***			
2.1.2 Carcases of pigs	Aerobic colony count			4 log cfu/cm^2 daily mean log	5,0 log cfu/cm^2 daily mean log	EN ISO 4833-1	Carcases after dressing but before chilling	Improvements in slaughter hygiene and review of process controls
	Enterobacte-riaceae			2 log cfu/cm^2 daily mean log	3 log cfu/cm^2 daily mean log	EN ISO 21528-2	Carcases after dressing but before chilling	Improvements in slaughter hygiene and review of process controls
2.1.4 Carcases of pigs	*Salmonella*	50	3	Not detected in the area tested per carcase		EN ISO 6579-1	Carcases after dressing but before chilling	Improvements in slaughter hygiene, review of process controls and of origin of animals
2.1.6 Minced meat	Aerobic colony count	5	2	5 × 10^5 cfu/g	5 × 10^6 cfu/g	EN ISO 4833-1	End of the manufacturing process	Improvements in production hygiene and improvements in selection and/or origin of raw materials

	E. coli	5	2	50 cfu/g	500 cfu/g	ISO 16649-1 or 2	End of the manufacturing process	Improvements in production hygiene and improvements in selection and/or origin of raw materials
2.1.7 Mechanically separated meat (MSM)	Aerobic colony count	5	2	5×10^5 cfu/g	5×10^6 cfu/g	EN ISO 4833-1	End of the manufacturing process	Improvements in production hygiene and improvements in selection and/or origin of raw materials
	E. coli	5	2	50 cfu/g	500 cfu/g	ISO 16649-1 or 2	End of the manufacturing process	Improvements in production hygiene and improvements in selection and/or origin of raw materials
2.1.8 Meat preparations	*E. coli*	5	2	500 cfu/g or cm^2	5,000 cfu/g or cm^2	ISO 16649-1 or 2	End of the manufacturing process	Improvements in production hygiene and improvements in selection and/or origin of raw materials

Key:
n = total number of samples to be tested
m = maximum level (results below this are within criteria)
M = maximum level allowed (results above this breach criteria)
c = allowable number of marginal results (number of results that criteria allow to be between *m* and *M*)

Annex 2. Summary of legislative controls per country

A2.1. United Kingdom

Overall responsibility for feed and food law is held centrally, but day-to-day responsibility for official control functions is divided between central and local Government.

The central competent authorities are as follows:

- Food Standards Agency (FSA)
- Food Standards Scotland (FSS)
- Department for Environment, Food and Rural Affairs (Defra)
- Department of Health and Social Care (DHSC)

The Food Standards Agency (FSA) is responsible for food safety and food hygiene in England, Wales and Northern Ireland. It works with local authorities to enforce food safety regulations and its staff work in meat plants in England and Wales to check the standards are being met.

Food Standards Scotland (FSS) is responsible for food safety, food standards, nutrition, food labelling and meat inspection in Scotland. FSS ensures that information on safety, standards and nutrition is independent, consistent, and evidence based.

The Department for Environment, Food and Rural Affairs (Defra) is the UK Government's department responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities in the United Kingdom of Great Britain and Northern Ireland. It is supported by 33 agencies and public bodies with a broad remit which plays a major role in people's day-to-day life, from the food and water consumed, safeguarding our natural environment, and sustaining a thriving rural economy.

The Department of Health and Social Care (DHSC) is the UK Government's department responsible for Government policy on health and adult social care matters in England, along with a few elements of the same matters which are not otherwise devolved to the Scottish Government, Welsh Government or Northern Ireland Executive.

At local level, day-to-day monitoring and enforcement of feed and food law are carried out by competent authorities including Local Authorities and Defra agencies, such as the Animal and Plant Health Authority (APHA), an executive agency, sponsored by Defra, the

Welsh Government and the Scottish Government. In addition, the FSA and FSS approves slaughterhouses, game handling establishments, cutting plants, and wholesale meat markets.

Port Health authorities are usually the UK local authority where a port or airport is located and are managed by local authorities who enforce regulations on behalf of central Government and carry out a range of health controls at the UK borders. These include checks on imported food, inspecting ships and aircraft for food safety and infectious disease control, as well as general public and environmental health checks. The FSA and Defra are responsible for the overall policy in the area of public and animal health for food and feed.

The Department of Agriculture, Environment and Rural Affairs (DAERA) has responsibility for food, farming, environmental, fisheries, forestry and sustainability policy and the development of the rural sector in Northern Ireland and is responsible to Defra in Great Britain for the administration of schemes affecting the whole of the United Kingdom. The Department also oversees the application of European Union agricultural, environmental, fisheries and rural development policy to Northern Ireland.

The UK is no longer a member of the European Union. EU legislation as it applied to the UK on 31 December 2020 is now a part of UK domestic legislation, under the control of the UK's Parliaments and Assemblies, and is published on legislation.gov.uk.

A2.2. Denmark

Danish Veterinary and Food Administration (DVFA) under the Ministry of Environment and Food of Denmark is the central competent authority responsible for food and feed safety, animal health and animal welfare (with the exception of fresh fish).

Food safety requirements and veterinary inspections are implemented by four Food Inspection Units (FIUs), three Veterinary Inspection Units (VIUs), and the Meat Inspection Unit (MIU) of the DVFA. The primary role of VIUs is to inspect farm animals. The MIU and 28 local meat inspection units located at slaughterhouses form the Meat Inspection Department (MID) which is responsible for inspection in slaughter establishments. The FIUs on the other hand are in charge of inspections in processing establishments, cold storage facilities and wholesale establishments. The FIUs and the MIU may share responsibilities for official control in small slaughterhouses with associated retail activities.

Danish Agricultural Agency (DAA) inspects certain aspects of the conditions in relation to hygiene on farms.

Denmark has adopted the European Union (EU) legislation pertaining to production of food of animal origin.

Monitoring of food safety in Denmark is coordinated by DVFA.

A2.3. Ireland

Two Government departments (Central Competent Authorities) are responsible for developing food policy and legislation for food and feed safety, animal health and animal welfare in Ireland:

- The Department of Agriculture, Food and the Marine (DAFM)
- The Department of Health (DOH)

These departments are supported in this role by the Food Safety Authority of Ireland (FSAI), under the Department of Health. The FSAI enforces food legislation through a service contract mechanism in conjunction with the corresponding official agencies.

DAFM is the official agency responsible for the development of policy and legislation and implementation of official controls for primary production of food, slaughter, cutting, preparation and processing of foods of animal origin, up to but not including retail level, as well as the import of food of animal origin. DAFM is also the competent authority for feed safety and animal health and welfare.

DOH is responsible for the development of policy/legislation and implementation of the rules for food of animal origin sold directly to the consumer, composite products and certain other products exempt from the oversight by DAFM. The Health Service Executive (HSE) is under DOH as well.

Low-volume meat slaughterhouses and processors are under the responsibility of local authorities.

As with all other EU member states, the EU regulations are the primary overarching laws for regulating the production of food of animal origin in Ireland.

With the help of corresponding official agencies, the FSAI monitors and reports on food business operators' activities and seeks continuous improvement and accountability through a programme of regular audits.

Environmental Health Officers of the HSE routinely and regularly inspect the sale and service of food at retail for compliance with the relevant EU and national legislation. The

food control work undertaken by Environmental Health Officers is done under a service contract between the HSE and the FSAI.

A2.4. Netherlands

The Ministry of Agriculture, Nature and Food Quality (MLNV) is in charge of policy-making and drafting legislation regarding food safety.

The Netherlands Food and Consumer Products Safety Authority (NVWA) is an independent agency under MLNV. It is in charge of organising official controls as per policies established by the ministry and supervises independent administrative public bodies. NVWA is also responsible for supervising the welfare of animals kept for commercial purposes.

Independent administrative public bodies such as Animal Health Service (GD Animal Health), AVINED, or PLUMINED are in charge of execution of official controls at regional level as per NVWA programmes.

The Netherlands has adopted the European Union (EU) legislation pertaining to production of food of animal origin.

The safety of food and consumer products is monitored by NVWA. NVWA also conducts audits to monitor effectiveness of controls through specific projects. The projects include Meat supply chain improvement plan, Improvement plan for approved assembly centres for cloven-hoofed animals, and Compliance monitor for red meat slaughterhouses and poultry slaughterhouses.

Some monitoring is delegated to semi-autonomous public bodies. For instance, GD Animal Health is commissioned by the Ministry of Economic Affairs and Climate Policy (EZK) and industry/umbrella organisations to monitor the health of all farm animals in the Netherlands (GD Animal Health).

The members of accepted quality schemes are potentially subject to reduced extent and frequency of official controls by NVWA (Ketenborging.nl).

A2.5. Poland

The Veterinary Inspectorate (VI) under the Ministry of Agriculture and Rural Development is the designated competent authority responsible for official controls of meat and meat products, including poultry.

The VI has a pyramidal structure with a direct line of command between central, regional and district levels. The General Veterinary Inspectorate (GVI) acts as the central competent authority, headed by the Chief Veterinary Officer. At regional level, there are sixteen Regional Veterinary Inspectorates (RVI), headed by Regional Veterinary Officers. However, all veterinary related activities, including meat inspection and monthly audits at each establishment, are conducted by 305 District Veterinary Inspectorates (DVIs), which are headed by District Veterinary Officers.

As with all other EU member states, the EU regulations are the primary overarching laws regulating the production of food of animal origin in Poland.

The safety of food, including meat and poultry meat and products thereof, at retail and wholesale level is monitored by the State Sanitary Inspection (SSI) under the Ministry of Health. The monitoring of food safety systems at primary production and food processing establishments is done by DVIs.

The SSI cooperates and coordinates activities with the GVI. Similar agreements for cooperation and coordination are replicated at regional and district levels with Voivodship and Poviat Sanitary and Epidemiological Stations (VSES and PSES).

A2.6. Ukraine

State Service of Ukraine on Food Safety and Consumers Protection (SSUFSCP) is the central competent authority.

Key legislation:

- Law of Ukraine No. 771/97-VR on basic principles and requirements for safety and quality of food products
- Order No. 548/2012 on approval of microbiological criteria for establishing food safety indicators
- Order No. 694/2013 on approval of the hygiene requirements for meat and poultry and indicators of its quality
- The Law on the Protection of Animals from Cruelty

State Service of Ukraine on Food Safety and Consumers Protection monitors the safety of foods.

A2.7. Canada

The Canadian Food Inspection Agency (CFIA) is the central competent authority which delivers all federally mandated programmes for food inspection, plant and animal health, including animal and plant products and by-products and production systems, and consumer protection as it relates to food. CFIA monitors all imports and exports for food products. It also monitors businesses that are engaged in the international or domestic movement of animals for compliance with regulations pertaining to the humane transportation of animals.

Health Canada (HC) is responsible for the country's federal health policy. Among other things, HC regulates veterinary drugs used in food-producing animals, pesticides, food additives, the uses of processing aids on red meat and poultry meat, food safety in terms of allergens and contaminants, and food processes, including food irradiation. HC works with CFIA and Canada Border Services Agency (CBSA) to enforce the rules set by HC.

Public Health Agency of Canada (PHAC) is an agency of the government of Canada that is responsible for public health, emergency preparedness and response, and infectious and chronic disease control and prevention. It carries out food-borne illness surveillance and investigations and helps with prevention and control.

All three of the above are overseen by the Minister of Health as part of their Health portfolio.

Main pieces of legislation are:

- Food and Drugs Act (FDA)
- Food and Drug Regulations (FDR)
- Safe Food for Canadians Act (SFCA)
- Safe Food for Canadians Regulations (SFCR)

Under SFCR, businesses are required to put in place preventive food safety controls for the slaughter of food animals from which meat products are derived as well as to manufacture, process, treat, preserve, grade, package or label food to be exported or sent across provincial or territorial borders. The SFCR require exporters to demonstrate that foods exported from Canada meet requirements such as preventive controls and

traceability plans that are consistent with internationally recognised food safety controls (CFIA, 2020a).

Businesses that conduct any activity in respect of food animals or meat products need to document their food safety controls in a written preventive control plan (PCP), outlining how the business will ensure that food is safe and fit for consumption and conforms to consumer protection and animal welfare requirements, as applicable (CFIA, 2020b).

Specific preventive controls may be prescribed by law (e.g., for *E. coli* O157/NM in raw beef products). In other cases, CFIA either provides recommendations or leaves it up to the businesses to select appropriate preventive controls (CFIA, 2020c).

Health of Animals Act (HAA) and Health of Animals Regulations (HAR) contain the Canadian legal requirements regarding animal health as well as humane treatment of animals. Requirements for the humane handling of food animals as well as for slaughtering are established in SFCR.

Canada, as a federal state, shares jurisdiction in animal health and food inspection activities with its provincial authorities. Therefore, provinces and territories also enact legislation to control foods produced and sold within their own jurisdictions. These laws are complementary to federal statutes.

Under SFCR, licence holders slaughtering food animals and producing meat products are required to have inspection services and a work shift with the CFIA. On application for a licence, CFIA will determine how many inspection stations will be needed and where (CFIA, 2019a).

Compliance with *Raised by a Canadian Farmer* On-Farm Food Safety Program and *Raised by a Canadian Farmer* Animal Care Program developed by Chicken Farmers of Canada is mandatory and is checked annually during audits. Similar on-farm food safety programs for red meat are currently in development (CFIA, 2019b).

A2.8. United States

The US Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS) has regulatory responsibility for the safety and accurate labelling of traditional meat, poultry, and certain egg products but often shares oversight with State and local government agencies.

The authority for FSIS to oversee red meat stems from the Federal Meat Inspection Act (FMIA) (21 U.S.C. §601 *et seq.*). The corresponding legislation for poultry is Poultry Products Inspection Act (PPIA) (21 U.S.C. §451 *et seq.*).

FSIS also enforces the Humane Methods of Livestock Slaughter Act (HMLSA) (7 U.S.C. §1901 *et seq.*) which specifically excludes poultry from the scope.

Under USDA Final Rule on Pathogen Reduction and HACCP Systems, before being granted Federal inspection, meat and poultry establishments must develop and implement HACCP (FSIS, 1996; 9 CFR Part 417).

Meat and poultry establishments under FSIS jurisdiction may opt for State inspection. States operate under cooperative agreements with FSIS. States' programs must enforce requirements “at least equal to” those imposed under the FMIA, PPIA, and HMLSA. Certain States have given up their poultry inspection programs – all meat and/or poultry establishments in these States are exclusively under FSIS inspection (FSIS, 2014).

A product produced under State Inspection is limited to intrastate commerce (cannot be exported to other States or abroad), unless a state additionally opts into the Cooperative Interstate Shipment Program (currently, eight States opted in) (FSIS, 2015).

The Food and Drug Administration (FDA) is responsible for assessing the safety of food additives in all foods and beverages. Therefore, FSIS consults with the FDA before compiling or amending its own lists of permitted treatments and food additives.

Under the FMIA and PPIA, meat establishments operate under a “continuous inspection” system, where an inspector is required to be present when the establishment is in operation although, in practice, this does not mean the presence every minute.

Meat and poultry processing plants are required to implement HACCP systems. As a result, the role of inspectors in processing plants is not limited to sensory inspection of the operation for evidence of sanitation problems but also includes tasks involving the monitoring of compliance with regulatory performance standards.

A2.9. Brazil

The Department of Inspection for Products of Animal Origin (DIPOA) under the Ministry of Agriculture, Livestock and Food Supply (MAPA) is the central competent authority that oversees and enforces regulations regarding production, marketing, import and export of animal origin products.

Federal Inspection Service (SIF) that ensures the quality of edible and non-edible products of animal origin destined for domestic and foreign markets as well as of imported products is also within DIPOA.

The National Agency of Sanitary Surveillance (ANVISA) under the Ministry of Health is responsible for the safety of consumer-ready or processed foods with the exception of those under MAPA. ANVISA oversees food additives and the toxicological aspects of the assessment of agrochemicals.

Key pieces of legislation include:

- Decree No. 9.013/2017 on industrial and sanitary inspection of animal products;
- Ordinance No. 326/1997 on approving Technical Regulation on the hygienic-sanitary conditions and good manufacturing practices for food manufacturers;
- Resolution No. 275/2002 on approving Technical Regulation on standard operating procedures applicable to food manufacturers and the checklist for good manufacturing practices for food manufacturing establishments.

Regional Inspection Service for Products of Animal Origin (SIPOA) overseen by DIPOA is responsible for scheduling, executing, monitoring, and evaluating inspection and oversight activities of animal products including activities conducted by the Federal Inspection Service (SIF). There are 10 decentralised SIPOA units, located in regions established by DIPOA.

Inspection at the local level is conducted by the SIF team located in each establishment registered with DIPOA. The SIF has the responsibility and authority to implement and enforce inspection laws at the establishment level.

A2.10. Chile

Agricultural and Livestock Service (SAG) is the official Chilean body responsible for supporting the development of agriculture, forests and livestock, through the protection and improvement of the health of animals and plants. SAG enforces and implements public policies in matters of animal health and livestock products. The Livestock Protection Division of SAG is responsible for the protection, maintenance and improvement of animal health and welfare, sanitary certifications as well as ensuring that products of animal origin are safe for human consumption and fit for export.

The Ministry of Health (MINSAL) is responsible for food sanitation, including meat and poultry, and the approval of food ingredients, labels and packaging of processed foods.

The Chilean Agency for Food Safety and Quality (ACHIPIA) under the Ministry of Agriculture is a Presidential Advisory Commission responsible for the development of the National Policy on Food Safety and Quality. ACHIPIA also takes a lead in implementing this policy via plans, programs and other measures developed by other authorities such as SAG, MINSAL etc. It serves as a coordinator between the authorities, food industry, scientific community, and consumers.

Relevant legislation includes:

- Decree No. 977/1996 on approving Food Sanitary Regulations (Titles III, IV, V, XI);
- Decree No. 736/1947 establishing Regulations for the prevention and prophylaxis of trichinellosis;
- Resolution No. 711/2002 on approving General Technical Standard No. 62 on veterinary medical inspection of animals for slaughter and their meat;
- Exempt Decree No. 1375/2010 on approving General Technical Standard No. 117 on veterinary medical inspection of poultry and poultry meat (including permitted antimicrobial treatments);
- Decree No. 118/2015 on approving Technical Standard No. 158 on the requirements for the application of the system of hazard analysis and critical control points (HACCP) in food establishments.

The regional Health Services under the Ministry of Health and SAG are in charge of monitoring and controlling compliance with the food safety regulations.

A2.11. Uruguay

General Directorate of Livestock Services (DGSG) of the Ministry of Livestock, Agriculture and Fisheries (MGAP) is the central competent authority responsible for official controls of slaughter and processing establishments, animal health controls etc. It has the legal authority and the responsibility to issue, implement, and enforce requirements.

Animal Industry Division (DIA) of the DGSG is in charge of authorising, registering, controlling and certifying meat products as fit for human consumption, both within the country and for export purposes. DIA supervises the performance of the official veterinary and non-veterinary inspectors at slaughterhouses and cutting plants.

Animal Health Division (DSA) of the DGSG is responsible for animal health controls, control and eradication of diseases etc.

General Directorate of Food Safety Control (DGCIA) of the Ministry of Livestock, Agriculture and Fisheries (MGAP) coordinates the implementation of surveillance actions in the area of food safety.

Important pieces of legislation:

- Decree No. 369/1983 on official regulation of veterinary inspection of products of animal origin
- Decree No. 315/1994 establishing the National Bromatological Regulation
- Resolution No. 96/80 Mercosur Technical Regulation on hygienic-sanitary conditions and good manufacturing practices for food manufacturing establishments
- Resolution No. 245/015 of DGSG on Procedure manuals of the *Escherichia coli* Control Program

Monitoring of food safety is coordinated by the General Directorate of Food Safety Control (DGCIA).

A2.12. Australia

Food Standards Australia New Zealand (FSANZ) is a statutory authority in the Australian Government Health portfolio.

FSANZ develops food standards (Australia New Zealand Food Standards Code) for both Australia and New Zealand. However, certain standards, including Standard 1.6.2 on processing requirements for meat, food safety standards in Chapter 3, and primary production and processing standards for poultry meat and red meat in Chapter 4, apply only in Australia. Food Standards Code also includes lists of permitted food additives and permitted processing aids (FSANZ, 2020).

In Australia, Food Standards Code is enforced by state and territory departments, agencies and local councils. States and territories monitor the compliance with the Code through their own legislation.

The Australian Department of Agriculture, Water and the Environment is responsible for the inspection and sampling of imported food.

A2.13. New Zealand

Food Standards Australia New Zealand (FSANZ) develops food standards (Australia New Zealand Food Standards Code) for both Australia and New Zealand. However, most standards applicable to meat production apply only in Australia. Lists of permitted food additives and permitted processing aids in the Food Standards Code apply in New Zealand (FSANZ, 2020).

The Food Act 2014 is the primary legislation governing food safety in New Zealand and is administered by the Ministry for Primary Industries.

Other important pieces of national legislation in New Zealand include the Animal Products Act 1999 as well as the Agricultural Compounds and Veterinary Medicines Act 1997, both also administered by the Ministry for Primary Industries.

In New Zealand, compliance with the Food Standards Code, Food Act 2014, and Animal Products Act 1999 is monitored by the Ministry for Primary Industries as well as by local councils.

A2.14. Botswana

The Department of Veterinary Services (DVS) of the Ministry of Agricultural Development and Food Security is the central competent authority. DVS is responsible for developing the legislative framework, setting up national programmes, policy matters and SOPs on animal health, food safety and animal welfare matters, in line with the international standards and importing country requirements.

Important pieces of legislation:

- Food Control Act
- Livestock and Meat Industries Act
- Livestock and Meat Industries (Meat Inspection and Control of Red Meat Abattoir) Regulations
- Meat Inspection and Control of Public Abattoirs and Export Slaughter Houses Regulations

Monitoring of food safety in Botswana is conducted by the Ministry of Health and Wellness with the assistance from the National Food Control Board with regional and local authorities participating as well.

A2.15. Namibia

The Directorate of Veterinary Services (DVS) of the Ministry of Agriculture, Water and Forestry (MAWF) is the central competent authority responsible for controls over the production and export of all animals and animal products, except fish and fishery products. Its Veterinary Public Health Division is responsible for the coordination of inspection in meat establishments and ensuring compliance with requirements of trading partners.

Important pieces of legislation:

- Animal Health Act 1 of 2011
- Prevention of Undesirable Residue in Meat Act 21 of 1991
- Regulations in Terms of the Prevention of Undesirable Residue in Meat Act, 1991 (No. 219 of 1994)
- Foodstuffs, Cosmetics and Disinfectants Ordinance 18 of 1979
- Regulations relating to the Standards of Food, Drugs and Disinfectants 1968
- Meat Industry Act 12 of 1981

New legislation on the safety of food in general and the regulations for the specific categories of food of animal origin are planned in the near future.

Monitoring of the safety of food of animal origin (with the exception of fish and fishery products) is coordinated by the personnel of the Veterinary Public Health Division of the DVS.

A2.16. India

Food Safety and Standards Authority of India (FSSAI) under the Ministry of Health and Family Welfare is the central competent authority responsible for the safety of all food, including meat.

FSSAI prescribes regulations on food under the Food Safety and Standards Act, 2006.

Other key legislation includes:

- Food Safety and Standards (Licensing and Registration of Food Businesses) Regulations, 2011
- Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011
- Food Safety and Standards (Contaminants, Toxins and Residues) Regulation, 2011
- Food Safety and Standards (Food Safety Auditing) Regulations, 2018
- Meat Food Products Order, 1973