RURAL INDUSTRIES RESEARCH
& DEVELOPMENT CORPORATION

Shelf life and microbiological safety of selected new and emerging meats

Destined for export markets

A report for the Rural Industries Research and Development Corporation

by Joanne Bobbitt

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Researcher Contact Details

Ms Joanne Bobbitt
Natural Resources and Environment

475 Mickleham Road

Attwood VIC 3049

Phone: 03 9217 4334
Fax: 03 9217 4111

Email: Joanne.Bobbitt@nre.vic.gov.au

In submitting this report, the researcher has agreed to RIRDC publishing this material in its edited form.

RIRDC Contact Details

Rural Industries Research and Development Corporation
Level 1, AMA House
42 Macquarie Street
BARTON ACT 2600

PO Box 4776
KINGSTON ACT 2604

Phone: 02 6272 4539
Fax: 02 6272 5877
Email: rirdc@rirdc.gov.au.
Website: http://www.rirdc.gov.au

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Foreword

Australian products have a distinct advantage in Asian export markets as they are perceived as being 'clean and green'. Importing countries from these regions impose stringent microbiological standards that must be attained, and establishing a microbiological baseline level for new and emerging meat products is essential in ensuring the success of any export market. Determining the current microbiological status of Australian new and emerging meats will allow industry to develop strategies to improve the shelf life of product, helping to cement export opportunities. The use of effective HACCP plans to ensure product safety is also an important factor in successfully accessing Asian markets. Development of generic plans will enable them to meet regulatory requirements more cost effectively.

A literature review of the current processing practices and resulting shelf life status of several new and emerging meat species including buffalo, kangaroo, emu, ostrich, crocodile, camel and rabbit, is included in this report. This review identified 2 meat industries, ostrich and rabbit, that would most benefit from the development of generic HACCP plans. Microbiological analysis of pathogenic, indicator, and spoilage bacteria on the 2 selected species is presented. Generic HACCP plans for the production of ostrich and rabbit meat are contained in this report.

This project was funded from RIRDC Core Funds which are provided by the Federal Government.

This report, a new addition to RIRDC's diverse range of over 800 research publications, forms part of our New Animal Products R&D program, which aims to improve processing, product development and diversification.

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- downloads at www.rirdc.gov.au/reports/Index.htm
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Peter Core
Managing Director
Rural Industries Research and Development Corporation

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Abbreviations

CCP	Critical control point
cfu	colony forming units
HACCP	Hazard Analysis Critical Control Point
NRE	Victorian Department of Natural Resources and Environment
QA	Quality assurance
RIRDC	Rural Industries Research and Development Corporation

Contents

Executive Summary

This project was undertaken to determine which of the new and emerging meat industries; specifically buffalo, camel, crocodile, emu, kangaroo, ostrich and rabbit, would best benefit from the development of generic Hazard Analysis Critical Control Point (HACCP) plans to improve the microbiological safety of their products and determine the shelf life of their products. A literature review of current processing practices and the shelf-life of these meat products has been written and used as the basis for selecting ostrich and rabbit carcass processing as those two industries for which generic HACCP plans were developed and shelf life trials were conducted.

The ostrich industry was suggested by the RIRDC New Animal Products Research Manager as a favourable option for the introduction of generic HACCP plans. This industry has an extensive range of meat products already developed and marketed, and has access to numerous export markets. The fear is that many of these products have arbitrarily assigned shelf lives, and validation of these would benefit not only single companies but also the industry as a whole. Development of generic HACCP plans, which still need to be modified for individual processors, can assist in the establishment of quality assurance programs which are regulatory requirements for the domestic and export meat works.

The emu industry has been experiencing a down turn in profitability in recent years and this industry would benefit more at this stage from increase in marketing of meat and meat products. Although support for this project has been expressed by the Emu Producers Association of Victoria, their priority was to increase the profitability of skin production rather than increase the microbiological quality of emu meat. It is unlikely that this species will be selected for the development of generic HACCP plans. However, this industry has some interesting issues which need addressing in terms of meat quality and microbiology. The Victorian association is interested in reducing the stress levels of birds currently being transported to abattoirs, and alternatively killing birds on farm. This would impact on current processing practices as the operations would have to demonstrate to regulatory bodies that this practice would not prove detrimental to the microbiological quality of the end carcass.

The camel industry will eventually benefit from microbiological investigation of camel meat products, as the majority of the published research in this area has been conducted overseas. Because of the small number of camels currently processed in Australia and the lack of dedicated abattoirs for this species, it is best to focus the activities of this project on another species, at least until the camel meat industry becomes more established with a strong domestic market and has vision to turn to exporting meat and meat products.

Recent research commissioned by RIRDC on "Maximising Marketing Opportunities for Buffalo Products" conducted a small shelf life trial on primal cuts and buffalo sausage. Coupled with the specifications outlined by TenderBuff® in the Northern Territory, this industry is already well placed for producing quality meat and meat products and has not been selected for further research in this project.

The crocodile industry is focussed on the production of skin from these animals because of the lucrative returns. Meat, therefore is a secondary by-product of the skinning process. The number of animals processed for meat is quite low compared to some other industries, and although further research into this meat industry would be interesting, the volume of product is still low and both domestic and export markets need to be expanded. However, there is always the concern with the association of crocodile meat with the foodborne pathogen *Salmonella* so it may still warrant considering this industry for the production of generic HACCP plans.

The rabbit industry was suggested by the RIRDC New Animal Products Research Manager as a favourable option for the introduction of generic HACCP plans. This meat industry has expanded in recent years, particularly due to the eradication programs of wild rabbits, and has an established domestic market with the potential to expand to the export arena.

The kangaroo industry is well established both for the production of skins and leather, and meat for both pet food and human consumption. The use of this animal as a meat production animal has suffered because of images of "Australia's coat of arms being shot under a spotlight". However, the industry has established export markets and has identified domestic marketing areas that can be improved to increase consumption. The industry has a microbiological monitoring program already in place for export licensed processing plants that are regulated by AQIS. This species has not been chosen for the development of generic HACCP plans.

The objective of this project was to identify two new and emerging meat species, with potential export market focus, most in need of microbiological investigation and to ensure the microbiological safety of these selected species by developing generic HACCP plans based on microbiological surveys.

Baseline levels of microorganisms on vacuum packaged ostrich primal cuts and whole rabbit carcasses were determined by laboratory investigation. Microbiological testing included total viable counts at 25°C (TVC), *Escherichia coli*, coliforms, Salmonellae, *E. coli* O157, *Staphylococcus aureus*, *Campylobacter jejuni, Aeromonas* spp., *Listeria monocytogenes*, *Yersinia enterocolitica* and *Clostridium perfringens*. The aim of this investigation was to identify which potentially pathogenic organisms may be present on the meat products, so that barriers can be put in place in the processing line to minimise the likelihood of such organisms surviving or multiplying to levels which may limit product acceptability.

The process for ostrich and rabbit processing was examined individually. The HACCP plans developed contain:

- description of the foodborne pathogens
- product description
- flow diagram of the process
- critical control point (CCP) determination
- HACCP audit table

A HACCP plan for each species processing line has been developed generically to allow application, with minor modification, to other processing plants.

Shelf life trials were conducted on vacuum packaged ostrich primals and whole rabbit carcasses. These products were used as these were the usual way such meat is presented to the respective customers. Product was collected from processing plants and stored at 4°C at VIAS and tested periodically for TVC, *E.coli*, coliforms, *Pseudomonas* spp., *Lactobacillus* spp. and *Brochothrix thermosphacta* until microbiological spoilage was evident. Ostrich vacuum packs were tested weekly while rabbit carcasses were tested every 2-3 days.

In summary:

- Pathogenic bacteria were not detected on either the ostrich primal cuts or the rabbit carcasses
- Chilling is the major CCP for the production ostrich primal cuts and rabbit carcasses
- The shelf life of vacuum packaged ostrich primals was limited to 4 weeks at 4°C
- Aerobic shelf life of rabbit carcasses at 4°C was limited to 3 days

Hygienic production of carcass meat is essential to ensure that contamination with potentially pathogenic bacteria is minimised. One must concede that such organisms will, at times be present on product, albeit in low numbers. The potential for proliferation of foodborne pathogens and spoilage organisms can be reduced by rapid chilling of product so as to limit bacterial growth and avoid conditions where toxins can be produced. Ostrich of good microbiological quality will keep for 4 weeks when stored in vacuum packaging at 4°C, while rabbit carcasses will keep for 3 days under aerobic storage at 4°C.

1. Introduction

In the current climate of heightened consumer awareness regarding food safety, food production is becoming increasingly scrutinised, with consumers much more aware of foodborne pathogens and the illnesses they cause, and also much more likely to take legal action in the event of a food-borne outbreak.

Australian meat processors have had to implement huge changes in recent years with the introduction of HACCP based quality assurance (QA) programs into both domestic and export abattoirs. The USDA/FSIS Pathogen Reduction Scheme (more commonly known as the MegaRegs) has changed the traditional visual inspection system of carcasses to one based on microbiological testing for the indicator organism *E.coli* and for Salmonellae. This system focuses predominantly on carcass meat from traditional meat species such as beef, lamb, pork and chicken. Generic HACCP plans for raw beef (NACMCF 1993) and for swine slaughter (USDA/FSIS 1994) have been available for several years. There is an industry need for generic plans to be developed for non traditional meat species such as buffalo, camel, crocodile, emu, kangaroo, ostrich and rabbit to set minimal standards for processing these species.

To complement continued improvements in microbiological quality and consumer safety of new and emerging meat via HACCP plans, a scientific approach to the determination of the shelf life of these meat products is also required. Some of the above mentioned meat species; particularly ostrich and kangaroo, already enjoy access to lucrative export markets. To maintain these markets, including the domestic market, the shelf life must be adequate to account for transit time and customer required storage time. Shelf life of meat depends on the microbiological quality prior to packaging and the cooling efficiency procedures and the maintenance of the cold chain (Gill and Harrison, 1985). Once these aspects are under control, and can be relied upon, the microbiological shelf life of the individual products must be determined by laboratory trials and not set arbitrarily.

Objectives

The objective of this project was to identify two new and emerging meat species, with potential export market focus, most in need of microbiological investigation and to ensure the microbiological safety of these selected species by developing generic HACCP plans based on microbiological surveys.

2. Methodology

Industry questionnaire

An industry survey was conducted by telephone interviews with managers (QA managers) of slaughter facilities processing buffalo, camel, crocodile, emu, kangaroo, ostrich and rabbit. The purpose of the questionnaire was to determine current processing practices for the species mentioned above. The questions which formed the basis of the survey are located in the attachment of the literature review. All responses were recorded.

Literature review

A literature review of the shelf life and a desk top review of the current processing practices of various new and emerging meats under investigation in this project was written and is located in Appendix 1 of this report.

Microbiological investigation of ostrich and rabbit meat products

A microbiological investigation of vacuum packaged ostrich primal cuts and boxed whole rabbit carcasses were undertaken for indicator and pathogenic bacteria.

Ostrich meat sampling

Ostrich packs were sampled by mass, that is, 10 gram of product was macerated with 90 ml of diluent (0.1% peptone water) from which most tests were performed. However, for Salmonellae and *Listeria monocytogenes* testing further 25 gram samples are required for addition to the appropriate enrichment medium. Ostrich packs were sampled and tested over a 5 week storage period.

Rabbit carcass sampling

Rabbit carcasses were sampled according to Australia standard AS1766.3.2 1979, rinse technique for poultry carcasses weighing under 2kg. This proved the most effective method of sampling as the whole carcass area is sampled. Carcasses were simply massaged with 500 ml diluent in sterile ‘stomacher bags’ and the resultant wash retained for testing. The carcasses were tested sampled and tested over an 8 day storage period.

Test methodology

The ostrich and rabbit samples were tested for the following bacteria according to Australian standard methods (or other similarly recognised methods):

- Total viable count at 25°C (TVC) (AS 1766.1.3 1991)
- *Escherichia coli* by Petrifilm™
- Coliforms by Petrifilm™
- Salmonellae (AS 1766.2.5 1991)
- *Staphylococcus aureus* (AS 1766.2.4 1994, surface spread method)
- *Listeria monocytogenes* (AS1766.2.16.1 1998)
- *Campylobacter jejuni* (AS1766.2.13 1991, surface spread method)
- *E. coli* O157 (adapted from Oxoid manual)
- *Aeromonas* spp. (adapted from Oxoid manual)
- *Yersinia enterocolitica* (cold enrichment method)
- *Clostridium* spp. (AS 1766.2.7 1991)

Development of HACCP plans

Flow charts for each processing line were constructed. Critical control points and limits were identified, based in part on the results from the microbiological data generated from the investigations described above and from known growth characteristics of those organisms.

Shelf life Trials

Shelf life trials were conducted on vacuum packaged ostrich primals and whole rabbit carcasses. Ostrich samples were stored at 4°C for 5 weeks and were sampled and tested on a weekly basis. Boxed rabbit carcasses were stored at 4°C for 8 days and were sampled on days 1, 3, 6 and 8 of storage. Samples were tested for the following bacteria according to Australian standard methods (or other similarly recognised methods):

- TVC (AS 1766.1.3 1991)
- *Escherichia coli* by Petrifilm™
- Coliforms by Petrifilm™
- *Pseudomonas* spp. (MIRINZ)
- *Lactobacillus* spp. (MIRINZ)
- *Brochothrix thermosphacta* (MIRINZ).

Microbiological spoilage is determined as 10^7 cfu per gram or whole carcass of any of the spoilage organisms (*Pseudomonas*, *Lactobacillus* or *Brochothrix*). The shelf life of the product was therefore set as the sampling day before this level was reached.

3. Results

Questionnaire responses

General comments

One processor from each of the meat species industries undertook the survey. Those chosen for the survey were by either consultation with the appropriate industry body, previous contact with the processor or simply those still processing the animals, as in the case of rabbit and emu. Participants in this survey processed one or more of the following new and emerging meat species; emu, ostrich, kangaroo, camel, crocodile, buffalo, rabbit. The majority of companies interviewed were abattoirs or a combination of abattoir/boning rooms processing more than one species. The rabbit and crocodile processors were single species works.

Of the processors interviewed, all had current HACCP plans (as required for either domestic or export licensing), which had been either prepared by company personnel or in consultation with external sources such as AQIS.

Except for kangaroo processing, the other respondents to this survey had arbitrarily set the shelf life of their product to either meet customer requirements or based on the shelf life achieved by other, similar species (for example buffalo was based on expected shelf life from vacuum packaged beef).

There were varied responses by the participants to the question of the individual industry need for generic HACCP plans. The ostrich and rabbit processors surveyed could see the benefit of developing generic HACCP plans. Some of the other processors; emu, buffalo and camel, were more reserved in their response to this question. They believed that as they were part of very small (and diminishing in the case of emu) industries that the benefit would not be great. Another concern which was raised was that such plans are sometimes written based on large plants and can be harder to implement in small plants where the process may be different. The crocodile processor believed it was the responsibility of AQIS to ensure processors were compliant with regulations, and so ensure adequate HACCP plans were used. This is a reflection of the belief that crocodile meat is merely a by-product of the skin industry, despite the fact that crocodile meat industry is worth approximately $1,000,000 per annum. The kangaroo processor maintained that the industry was well established and advanced with processes and HACCP plan effectiveness, and would not benefit from the development of generic HACCP plans.

All the participants, except for the emu processor who was only providing a contract kill service, were interested in value adding their products. The rabbit processor suggested the idea of lavender flavoured meat by feeding. The crocodile processor believed there would be market potential for value added products. Both the buffalo and kangaroo processors were interested in value adding their product, with a focus on marketing the product.

Emu

The emu works is a contract processor, killing mainly to supply the smallgoods industry, slaughtering 125 birds per day. All birds processed are farmed. The Australian standard states that birds should be off feed for 24 hours prior to transport, though this is not guaranteed. The distance travelled to the abattoir varies depending on the farm. Birds are kept in lairage either overnight or up to 24 hours. Prior to processing birds are moved from the lairage yards to the crush where they are electrically stunned. The slaughter process is as follows:

1. Bird shackled by the toenail
2. Transferred to the rail
3. Thoracic stick and cut through
4. Hand pluck with or without shearing
5. Bung
6. Skin
7. Defat
8. Gut
9. Split/separate hips/whole
10. Weigh
11. Chiller

The whole process takes approximately 30 minutes per bird, not including chilling. Birds are boned the following day. The process is monitored by time/temperature critical control points, and less so by microbiological verification using *E. coli.*

Product is vacuum packaged with the shelf life arbitrarily set.

Ostrich

The ostrich works is export licensed to kill ratites, supplying the wholesale and retail sectors, slaughtering 900 birds per week. All birds processed are farmed. Birds are kept off feed and water for 24 hours prior to transport. Transportation from the farm to the abattoir is 500 km. Birds are kept in lairage for 24 hours. Prior to processing birds are restrained and electrically stunned. The slaughter process is as follows:

1. Thoracic stick and cut through
2. Break neck
3. Remove head
4. Pluck feathers
5. Remove legs
6. Skin
7. De-fat
8. Eviscerate
9. Post-mortem inspection
10. Remove neck
11. Remove ribcage
12. Inspect and trim carcass
13. Split carcass

14. Chill
15. Pre-boning trim
16. Bone carcass
17. Pack product
18. Chill
19. Load-out
20. Transport

The whole slaughter/dressing process takes approximately 1.5 hours per bird. The process takes so long as feathers are removed by hand and great care must be taken to remove the skin that is valuable for leather production. Birds are boned the following day. The process is monitored by time/temperature critical control points, and by microbiological verification using *E. coli.*

Product is vacuum packaged with the shelf life arbitrarily set.

Kangaroo

The kangaroo works is export licensed to process game including wild boar, goat and deer, and is the largest kangaroo processing plant in Australia. The company supplies the wholesale, retail, food service and manufacturing sectors, slaughtering 850 animals per day. All macropods processed are wild, and are therefore killed and partially processed in the field utilising 'field' chillers. Carcasses can be held in these chillers for 3-4 days before they are transported to the processing plant. The slaughter process is as follows:

1. Animals are shot at night (by licensed shooters)
2. Carcasses are gutted (leaving kidneys, lung and liver for inspection purposes)
3. Carcasses are hung and bled on side of vehicle
4. Carcasses are moved to the field chiller within 2 hours of sunrise
5. Chilled carcasses transported under refrigeration to the processing plant
6. De-hide
7. Process similarly as for beef
8. Boned
9. Vacuum packaged

The process is monitored by time/temperature critical control points, and by microbiological verification using *E. coli.*

The vacuum packaged product has a shelf life of 5 weeks which was determined by microbiological testing.

Camel

The camel works is a domestic licensed plant, processing several species including sheep/lamb, beef, goat and deer. The company is the only camel processor in Australia and supplies the retail sector, specifically butcher shops. Camel processing is very small, only slaughtering 6-7 animals per week. The majority of camels processed are feral which are transported live to the abattoir following mustering. The camels are transported from the Northern Territory to northern South Australia. It is unclear if mustered animals are kept off feed prior to transportation, and animals may be kept in lairage at the abattoir for in excess of 3 weeks if more than 6-7 animals arrive for slaughter. The slaughter process is as follows:

1. Stunned by captive bolt

2. Stuck
3. Suspended
4. Neck skun and removed
5. Hide prepared for removal
6. Hide removed
7. Brisket opened
8. Eviscerated
9. Carcass split
10. Water wash
11. Chilled

The process is monitored visually and by temperature recording. Camel carcasses are randomly tested microbiologically using *E. coli* verification based on the domestic requirements for beef.

The vacuum packaged product has a shelf life of 6-8 weeks which was determined by the plant's client, and so it is unclear if this was based on microbiological analysis or arbitrarily set.

Crocodile

The crocodile works is an export licensed processing plant for crocodiles only. The company supplies the wholesale sector with half of its product used in the retail and food service sectors. Approximately 30 animals are slaughtered per week. All the crocodiles processed are farmed and are shot prior to transportation to the abattoir. The carcasses must be below 4°C before they reach the boning room for opening, and are hung post slaughter and cleaned prior to boning. The process is as follows:

1. Slaughtered at farm by .22 rifle to the back of the head
2. Chill/hang
3. Transport to boning facility
4. Check temperature of carcass upon arrival
5. Chill
6. Clean/bung
7. Separate skin
8. Skin
9. Eviscerate
10. Bone (sticking wound removed)
11. Sanitise meat (1% acetic acid for ~10 seconds) depending on market (not EU)
12. Drain meat
13. Vacuum packaging/labelling
14. Blast freezer
15. Carton and weigh
16. Freezer storage
17. Dispatch

The process is monitored at each step as it is all processed manually, and by temperature recording. At this stage routine microbiological monitoring of crocodile meat is not required, though is carried out by this processor approximately 4 times a year, testing for *Salmonella* only.

The vacuum packaged product is frozen and has been given a shelf life of 2 years as stipulated by the regulatory authorities.

Buffalo

The buffalo works has a domestic license to process mixed species. The company supplies the food service industry, slaughtering 6 buffalo per 6 weeks. All buffalo processed are farmed, transported live to the abattoir without feed being withdrawn prior to transport. Transportation takes approximately 1.5 hours. Animals are held in lairage between 0-12 hours. The slaughter process is the same as that for beef and is as basically as follows:

1. Stun by captive bolt
2. Stick/bleed
3. Shackle
4. Fore hocks removed
5. Hide removal
6. Rodding
7. Bunging
8. Head removal
9. Flanking/brisket saw
10. Evisceration
11. Trim
12. Carcass split
13. Final wash
14. Chilling
15. Transport/further processing

The process would be monitored similarly to that required for domestic beef production.

The vacuum packaged product has been given an arbitrary shelf life of 6 weeks based on similar beef products, with no studies to corroborate this.

Rabbit

The rabbit operation has a domestic license to kill rabbits only, supplying the food service and retail sectors, slaughtering 80 animals per day. All animals processed are farmed. Animals are kept off feed and water for 24 hours prior to transport. Transport distance varies from 1.5 to several hours. Rabbits are kept in lairage at the abattoir for approximately 16 hours. The slaughter process is as follows:

1. Stun by captive bolt
2. Decapitated
3. Hung
4. Skun
5. Eviscerated
6. Cleaned/washed

7. Chill

The whole slaughter/dressing process takes approximately 30 minutes per rabbit. The processing area is maintained at 14°C. Carcasses are chilled for a minimum of 4 hours, though more usually they are chilled overnight, to ensure their temperature is below 10°C. The process is conducted without temperature monitoring documented or microbiological verification.

Fresh product has been given an arbitrary shelf life of 1 week, without microbiological validation. If product is not loaded out after 2 days, it is frozen with no indication of the shelf life of the frozen product.

Microbiological investigation of ostrich meat and rabbit carcasses

The qualitative microbiological assessment of the ostrich meat and rabbit carcasses is detailed in Table 1, below.

Table 1: Faecal indicators and foodborne pathogen testing of ostrich meat and rabbit carcasses

MICROORGANISM	**PRODUCT**	
	Ostrich primals	**Rabbit carcasses**
E. coli	detected	detected
Coliforms	detected	detected
Salmonella	not detected	not detected
E. coli O157	not detected	not detected
Listeria monocytogenes	not detected	not detected
Yersinia enterocolitica	not detected	not detected
Staphylococcus aureus	not detected	not detected
Clostridium perfringens	not detected	not detected
Campylobacter jejuni	not detected	not detected
Aeromonas spp.	not detected	not detected

Development of HACCP plans

The HACCP plans for each of the 2 meat species was based on the above microbiological findings with respect to setting control measures. The generic HACCP plans are in appendices 2 and 3.

Shelf life trials

Table 2. Microbiological examination of vacuum packaged ostrich primals stored at 4°C for 5 weeks, for spoilage and indicator organisms. Packs were sampled on the day of packaging (Day 0) and weekly thereafter. Results expressed as mean $\log_{10}$ count per gram.

	Storage time					
Organism	Day 0	Week 1	Week 2	Week 3	Week 4	Week 5
TVC	3.1	5.1	6.53	7.67	7.79	8.09
Pseudomonas	3.18	4.49	5.48	4.88	5.99	5.44
Brochothrix	nd	0.99	1.46	nd	3.31	3.45
Lactobacillus	0.52	3.49	1.96	3.68	2.23	6.03

nd: none detected

Table 3. Microbiological examination of rabbit carcasses, stored aerobically at 4°C for 8 days, for spoilage and indicator organisms. Carcasses were sampled the day following processing (Day 1) and on days 3, 6 and 8 thereafter. Results expressed as mean $\log_{10}$ count per carcass.

	Storage time			
Organism	Day 1	Day 3	Day 6	Day 8
Total Viable Count	5.69	7.69	10.26	11.79
Pseudomonas spp.	5.34	7.69	10.82	12.04
Brochothrix spp.	4.76	6.18	8.85	10.32
Lactobacillus spp.	nd	5.30	6.18	5.76

nd: none detected

4. Discussion

Generic HACCP plans for Rabbit and Ostrich Meat Processing

The Food Standards Programme of the *Codex Alimentarius* defines 12 steps for the development and implementation of HACCP plans, which includes the 7 principles of HACCP.

The first 5 steps are:

1. Assemble HACCP team and define scope of HACCP plan
2. Describe the product and distribution
3. Determine what is the intended use of product
4. Prepare a process flow diagram for the product
5. Verify the flow diagram on production site.

The following steps are the 7 principles of HACCP

6. List all potential hazards (biological, chemical, physical) associated with each step in the process flow diagram, conduct a hazard analysis and consider control measures for each hazard
7. Determine critical control points (CCPs)
8. Establish critical limits for each CCP
9. Establish monitoring system for each CCP
10. Establish corrective action plan should a CCP fall out of control
11. Establish verification procedures
12. Establish record keeping and documentation.

To implement a HACCP plan into a food production system to control food safety, SCARM Report 60 recommends the following activities should be undertaken

- Determine what degree of training is required for all staff members of the food production establishment to ensure full understanding of HACCP and its implications to the company
- Commence CCP monitoring and keep records which can be used for trend analysis
- Obtain information on microbiological tests required by regulatory authorities in addition to company verification activities.

HACCP documentation required to demonstrate the above steps have been followed include:

- Definition of terms of reference of the HACCP plan
- Amendment register
- HACCP team register
- Product description and intended use
- Process flow chart
- Potential hazards and hazard analysis
- Hazard control measures
- CCP determination

- Critical limits for CCPs
- Monitoring plans
- Corrective action plan
- Hazard audit table
- Work instructions for step by step instruction for the operator (essential for monitoring CCPs and for training purposes)
- Records to show control at each CCP (monitoring records and corrective action)
- Additional monitoring requirements (Acceptable Quality Levels as given in AS4466:1997 and AS5010:2001)
- Frequency, methods and records of validation
- Frequency, methods and records of verification
- Records of HACCP plan review

The generic HACCP plans for the production of rabbit and ostrich meat which follow contain the following elements

- Product description
- Process flow diagram
- Potential biological hazards
- Hazard analysis
- CCP determination tables
- HACCP audit table which details
- Hazard control measures
- CCP critical limits
- CCP monitoring plans
- Corrective action

Prerequisite programs to support the HACCP plan, which must be monitored to ensure effectiveness and records maintained include,

- Hygiene and sanitation procedures
- Personal hygiene and general work instructions
- Cleaning and approved chemicals schedules
- Calibration schedules and monitoring forms
- Product identification - recall procedure
- Design and maintenance of the plant structure
- Design and maintenance of the plant equipment
- Training in hygiene and work procedures
- Separation and disposal of material unfit for human consumption
- Waste disposal and effluent control
- Water supply
- Pest and vermin control program schedule

The AQIS Meat Safety Quality Assurance System (MSQA) recommends Standard Operating Procedures (SOPs) should be written for

- Maintenance including preventive maintenance
- Livestock including animal care
- Slaughter
- Boning
- Refrigeration
- Product traceability and recall
- Management review
- Internal audit
- Training
- Calibration

The Australian Standards for the hygienic production of rabbit and ratite meat requires that the 20 clauses of AS/NZS ISO 9002 are adopted.

The HACCP plans for ostrich meat and rabbit carcass processing have been developed generically to allow application to other processing plants, with minor modification. These plans rely largely on adequate temperature control of the meat products, where chilling is identified as a CCP.

The product tested in this research was of high microbiological standard with respect to pathogenic bacteria, as the common foodborne pathogens were not detected from either rabbit or ostrich samples. This is not to say, that these bacteria will not be detected from rabbit or ostrich meat, and processors should not relax their vigilance in producing high microbiological quality meat.

Reasonable aerobic shelf-life (6 days) of rabbit carcasses can be achieved with good microbiological quality product at the outset and appropriate storage conditions (4°C). Storing carcasses below 4°C will improve the storage time.

The shelf life achievable from vacuum packaged ostrich meat was found to be 4 weeks at 4°C. This storage temperature was selected as it is not always possible to ensure product is kept below 4°C which is desirable for vacuum packaged meat. However, storage below 4°C is preferable and if possible will lead to an increased storage life.

The information gained from the shelf life trials for these 2 meats may be utilised to help open up as yet untapped markets, provided a) appropriate temperatures are maintained along the cold chain, b) only good quality product is packed and c) consumer acceptance of such product is assessed.

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Appendix 1

Review of Shelf life and Processing Practices of Various New and Emerging Meats

Agriculture Victoria, Attwood

DAV-181A Shelf life and microbiological safety of new and emerging meats destined for export markets

March 2001

Introduction

The microbiological assessment of meat required by regulatory authorities in Australia, and to a large extent in countries importing Australian meat, focuses on monitoring of indicator organisms. Generally testing is undertaken for *Escherichia coli*, to indicate the likely presence of pathogenic bacteria such as *Salmonella*. Domestic and export regulatory authorities also require less frequent specific testing for *Salmonella* which are associated with faecal contamination. Testing for these organisms is essential to ensure that the particular meat process, whether in the abattoir, the boning room or packaging plant, is in control. Test results can be used to verify the Hazard Analysis Critical Control Point (HACCP) plan the individual plant has implemented. Meat authorities around Australia now require the implementation of HACCP plans, which must be regularly audited by a third party. Export licensed meat processing plants must also comply with the Australian Quarantine Inspection Service (AQIS) Meat Safety Quality Assurance System (MSQA) for fresh meat and processed meat products (Anon.). State meat authorities, such as the Victorian Meat Authority (VMA) require the plants to adhere to the Australian Standards which are endorsed by the Meat Standards Committee (MSC) of the Standing Committee on Agricultural Resource Management (SCARM). These standards are in the form of a series of reports that are used as the basis for on-plant quality assurance (QA) programs. This series of reports includes:

- Australian Code of Practice for Poultry Processing (SCARM Report 18)
- Australian Standard for the Construction of Premises Processing Meat for Human Consumption (SCARM Report 53)
- Australian Standard for the Hygienic Production of Meat for Human Consumption (SCARM Report 54)
- Australian Standard for the Construction of Premises Processing Animals for Human Consumption (SCARM Report 55)
- Australia Standard for Transportation of Meat for Human Consumption (SCARM Report 56)
- Australian Standard for the Production of Game Meat for Human Consumption (SCARM Report 57)
- Australian Standard for the Production of Poultry Meat for Human Consumption (SCARM Report 58)
- A Guide to the Implementation and Auditing of HACCP (SCARM Report 60)
- Australian Standard for Hygienic Production of Natural Casings for Human Consumption (SCARM Report 68)
- Australian Standard for the Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption (SCARM Report 75).

Export licensed meat processing establishments must comply with the *E. coli* and Salmonella monitoring (ESAM) program (AQIS notice Meat 2000/09). Under the ESAM program the establishment must test product for *E. coli* and *Salmonella* spp. Results of *E. coli* tests are used to verify process control, and the surveillance of product for *Salmonella* is used to demonstrate pathogen reduction, and combined testing for both these organisms to verify slaughtering and chilling operations is enforced and regulated by AQIS (AQIS notice Meat 2000/09).

Much of the focus of the regulatory bodies is on the control of pathogenic bacteria and the food safety risks associated with meat production. Such surveillance is vital to the long term survival of the entire meat industry, as the consumer backlash which can result as a reaction to a foodborne disease outbreak can be devastating. However, major costs borne by the industry also come in the form of product rejection and discounting. These costs are a consequence of bacterial contamination of product with spoilage bacteria. This is true for not only boned/packaged product but also carcasses.

The danger many processors fall into is to arbitrarily designate a shelf life to a particular product based on either customer requirements, what has been achieved for other products from the same or different species, or by purely organoleptic assessment such as sight and smell. Processors need to be aware of the danger of assigning product a shelf life without microbiological validation, particularly when there are is a break in the cold chain. Shelf life trials need to be conducted not only by individual plants but should be conducted on individual products. This may be for new products, for similar products from different species, and where the same product is subjected to different storage conditions. Shelf life validation is costly to the individual company, however, the microbiological results provide documented evidence to support the QA program of the plant, and also can assist in managing supplier/customer expectations at either end of the chain.

Shelf life of meat is limited by time and temperature and these are also the major factors affecting the survival of pathogens. Time/temperature data logging of product is essential, particularly when product is destined for an export market where there are many opportunities for a break in the cold chain to occur. Such data is used to monitor the conditions to which product is subjected and validates the process as required by the Export Meat Orders. AQIS supervision of airfreight load outs of meat, game and poultry meat and meat products at freight forwarders may be required depending on the type of QA scheme the export plant is employing under and where chilled and/or frozen product is held, stored and chilled (AQIS notice Meat 99/23). AQIS stipulates temperature and loading requirements for airfreight consignments of chilled product such that chilled offal must be below 3°C prior to loading, chilled goods must be below 4°C, and must meet the temperature requirements of the importing country (AQIS notice Meat 200/16).

Apart from satisfying the export regulatory requirements, time/temperature data logging of chilled and frozen product can be used to predict the remaining shelf life of product destined for an export or domestic market, provided microbiological information on the product taken at the processing plant is available and that there is a model developed for

the organism of interest. Predictive microbiology software is available commercially for many pathogenic and some spoilage bacteria. It is a powerful tool in the hands of a trained microbiologist, but care must be taken as the shelf life estimations provided by such products are purely estimations and should not be used to replace microbiological validation of shelf life.

The objective of this review is to detail current processing practices of several meat industries, specifically, ostrich, emu, camel, buffalo, crocodile, rabbit and kangaroo. It will also highlight those industries with expanding markets that may benefit from establishing generic HACCP plans to ensuring on-plant QA programs are aimed at food safety. The shelf life status of meat products of the above industries will also be reviewed, and identify those products that require microbiological validation of shelf life.

Ostrich

Introduction

Ostrich meat has been exported to the European Union (EU) and various Asian countries including Singapore and Malaysia, and there is the potential to expand into other export markets.

Processing practices

This industry has the advantage of having a specific Australian Standard for the Hygienic Production of Ratite (Emu/Ostrich) Meat for Human Consumption (SCARM Report 72) which stipulates the quality performance outcomes required to meet this standard.

The basic slaughter technique for ratites in Australia is adopted from the South African method of slaughtering ostriches (Sales and Horbanczuk, 1998). Once the bird is stunned it is hung by the legs from a horizontal bar (Sales and Horbanczuk, 1998). There are 3 acceptable positions to place the tongs when stunning the ostrich; between the eye and the ear on both sides of the head, below the ear on both sides of the head, and diagonally between the top and bottom of the head (Lambooij *et al* 1999a). The desirable minimal electrical stunning current is 500mA for ostriches with exsanguination within 20s of stunning (Lambooij *et al* 1999a). Ostriches can be killed by applying current in excess of 6s (Lambooij *et al* 1999a). The bird is then exsanguinated by severing the major blood vessels under the head (Sales and Horbanczuk, 1998). Following bleeding the feathers are plucked, the head removed and the body is skinned (Sales and Horbanczuk, 1998). The body is then hung from the bar by the wings, the feet are removed, the carcass is split and the viscera removed (Sales and Horbanczuk, 1998). The legs of the carcass are hot boned, then chilled before boning into primal or retail cuts as appropriate (Sales and Horbanczuk, 1998). Meat undergoes rapid post-mortem tenderisation (Berge *et al* 1997). A critical factor associated with hot boning of carcasses is the temperature reduction of the resultant meat to 7°C (AQIS notices Meat 94/2, Meat 00/06). This is important not only in terms of controlling the growth of enteric pathogens, but also to limit the growth of spoilage bacteria that increase in number during the boning process. Huchzermeyer (1997) warns of several public health risks associated with processing ostrich meat in South Africa ranging from viral, bacterial and parasitic agents, antimicrobial residues, though most of those listed were considered unlikely to cause problems in humans. However, *Salmonella* is a real risk and ongoing monitoring of this pathogen required by export licensed works should be employed to ensure that this hazard is kept under control.

The Authority for Uniform Specification Meat and Livestock (AUS-MEAT) has produced a manual, developed in conjunction with the Australian Ostrich Company, containing "specifications and tenderness rating for primal cuts, menu/prepared dishes and anatomical information" (Anon. 1998b) which ensures the industry has a uniform approach to boned meat.

There are several AUS-MEAT licensed ratite slaughtering facilities in Victoria (http://www.ausmeat.com.au/standards/malay/default.asp?vic); AGP in Wycheproof, Goldfields Turkeys P/L at St. Arnaud, Ozimeats P/L at Pyramid Hill and The Emu Company P/L at Myrtleford**.** Eleven cuts are derived from the ratite drumstick: inner

mid drum, inner outside drum, inside drum, round, flat fillet, oyster fillet, fan fillet, full rump, outside fillet (http://www.ogme.com/other_game/emuostcuts.htm).

Shelf life status

The Australian Ostrich Association website (http://www.aoa.asn.au/information/meat/meat.html) recommends all ostrich meat products be stored at or below 4°C and warns against refreezing thawed product, which would affect meat quality. There is a range of ostrich meat products detailed at this site which also gives shelf life and storage instructions. However, it is unclear from the site how these products are packaged, though it is assumed from the time frames specified that they must be packed under modified atmosphere such as vacuum packaging. These products include:

- Salami, sandwich roll and ostrich fillet can be stored unopened under refrigeration for 8 weeks and can be frozen though product must be used within 5 days of thawing,
- Cabana and saveloys can be stored unopened under refrigeration for 3 weeks and can be frozen though product must be used within 5 days of thawing,
- Ostrich burger mix and sausages can be stored unopened under refrigeration for 5 days and can be frozen though product must be used within 5 days of thawing,
- terrine (combined with crocodile meat) can be stored unopened under refrigeration for 28 days and can be frozen for up to 6 months though product must be used within 4-5 days of thawing,
- paté can be stored unopened under refrigeration for 5 weeks and can be frozen though product characteristics will change. No recommendations of how or when to consume following thawing are detailed.

The observed high pH of ostrich meat renders it susceptible to bacterial spoilage (Paleari *et al*, 1998, Lambooij *et al* 1999b). Otremba *et al* (1999) reported pHs of previously frozen ostrich steaks and ostrich ground meat as 6.4 and 6.2, respectively. On subsequent vacuum packaging and storage at 0°C±2°C, the recommendation of the researchers was that "previously frozen, vacuum-packaged, ostrich meat stored under refrigeration conditions should be used within 10 days". However, based on the microbiological data alone this study demonstrates that the dominant spoilage bacteria of vacuum packaged meat (*Lactobacillus*) remained well below spoilage levels at day 28, when the study concluded. Gill *et al* (2000) found the total aerobic count per square centimetre detected from ostrich carcasses to be approximately $\log_{10}$ 2.15, which falls into the excellent range according to the Meat Standards Committee (Anon., 1998a). Counts of total bacteria alone cannot be used as a measure of shelf life of meat products, but do give a good indication of the general hygiene of the meat. It should be noted that the abattoir involved in the study (Gill *et al* 2000) was a small research abattoir, not operating under commercial conditions, therefore microbiological counts on carcasses are likely to be lower than in a commercial operation. The proportion of specific spoilage bacteria should be determined in a microbiological investigation of stored meat. Bacterial spoilage of product is defined as occurring when counts of spoilage organisms reach 10^7 colony forming units per square centimetre or gram (cfu/cm^2 or cfu/g) of product. The main spoilage bacteria associated with meat are *Pseudomonas* spp. in the case of aerobically stored meat, and *Lactobacillus* spp. or *Brochothrix thermosphacta* in the

case of vacuum or modified atmosphere packaged product (Brown, 1982). *B.thermosphacta* dominates the meat flora in high pH meat (Brown, 1982).

Summary

One advantage of high pH meat is its water holding capacity, which is highly desirable for the smallgoods industry because of the reduced need to use moisture retaining agents (Fisher *et al* 2000, Böhme *et al* 1996). Such products are currently being manufactured in Australia from Australian ostrich meat, some of which are detailed above. The Australian ostrich industry is well advanced in terms of what is required by the regulatory authorities, and with establishing Australian specifications for ostrich meat cuts. The further processing of ostrich meat is successful, with a range of smallgoods available. This variety of products ensures the industry will hold places in both the domestic and export markets. The industry would benefit from validation of shelf life of some of its most popular products, particularly those destined for export markets where breaks in the cold chain are likely to occur and which can compromise the integrity of the product during transit.

Emu

Introduction

The emu industry in Australia is based on processing only farmed birds, wild-farming of emus is prohibited in all states. The emu industry is still in its infancy in terms of marketing its major products (meat, oil and leather) with supply exceeding demand (O'Malley, 1997, http://www.parliament.vic.gov.au/enrc/unff/report/util4-06.htm).

Processing practices

Despite the downturn of this industry in recent years, Australian regulatory bodies have developed standard processing procedures for the production of emu meat. The Australian emu industry has the advantage of having a specific Australian Standard for the Hygienic Production of Ratite (Emu/Ostrich) Meat for Human Consumption (SCARM Report 72) which stipulates the quality performance outcomes required to meet this standard.

Basic slaughter technique for ratites in Australia is adopted from the South African method of slaughtering ostriches (Sales and Horbanczuk, 1998). Once the bird is stunned it is hung by the legs from a horizontal bar (Sales and Horbanczuk, 1998). The bird is then exsanguinated by severing the major blood vessels under the head (Sales and Horbanczuk, 1998). Following bleeding the feathers are plucked, the head removed and the body is skinned (Sales and Horbanczuk, 1998). The body is then hung from the bar by the wings, the feet are removed, the carcass is split and the viscera removed (Sales and Horbanczuk, 1998). The legs of the carcass are hot boned, then chilled before boning into primal or retail cuts as appropriate (Sales and Horbanczuk, 1998). A critical factor associated with hot boning of carcasses is the temperature reduction of the resultant meat to 7°C (AQIS notices Meat 94/2, Meat 00/06). This is important not only in terms of controlling the growth of enteric pathogens, but also to limit the growth of spoilage bacteria that increase in number during the boning process. There are several AUS-MEAT licensed ratite slaughtering facilities in Victoria; AGP in Wycheproof, Goldfields Turkeys P/L at St. Arnaud, Ozimeats P/L at Pyramid Hill and The Emu Company P/L at Myrtleford (http://www.ausmeat.com.au/standards/malay/default.asp?vic).

Eleven cuts are derived from the ratite drumstick: inner mid drum, inner outside drum, inside drum, round, flat fillet, oyster fillet, fan fillet, full rump, outside fillet (http://www.ogme.com/other_game/emuostcuts.htm).

Emu meat is sensitive to oxidation because of the high pigment content of the muscle. This poses some limitations to the potential storage time under aerobic packaging at refrigeration temperatures (Berge *et al* 1997), regardless of bacterial load. Like ostrich meat, emu meat suffers from the high ultimate pH characteristic of dark, firm and dry (DFD) meat. DFD is observed particularly in beef and pork, and is usually attributed to long term stress of animals prior to slaughter. Increased stress on the animal prior to slaughter can usually be attributed to increased handling, transportation and mixing during lairage. This prolonged stress results in depletion of muscle glycogen which cannot then be produced with the onset of rigor, and hence the ultimate muscle pH from such animals does not drop as dramatically as that of unstressed animals (Brown, 1982). Such meat is more susceptible to bacterial spoilage than normal meat, though DFD meat does have the advantage of good water

holding capacity which is desirable for the production of smallgoods (Fisher *et al* 2000).

Shelf life status

Gill *et al* (2000) found the total aerobic count per cm^2 detected from emu carcasses to be approximately $\log_{10}$ 2.82, which falls into the excellent range according to the Meat Standards Committee (Anon., 1998a). It should be noted that the abattoir involved in the study was a small research abattoir, not operating under commercial conditions, therefore microbiological counts on carcasses are likely to be higher in a commercial operation. The total count of bacteria alone cannot be used as a measure of shelf life of meat products, but does give a good measure of the general hygiene of the meat. The proportion of specific spoilage bacteria should be determined in a microbiological investigation of stored meat.

Summary

One advantage of high pH meat is its water holding capacity, which is highly desirable for the smallgoods industry because of the reduced need to use moisture retaining agents (Fisher *et al* 2000, Böhme *et al* 1996). Such products are currently being manufactured in Australia from Australian ostriches, and the same can be done using emu meat. An increase in the range of emu meat products available with validated shelf life would assist the industry in accessing more markets both domestically and overseas. The industry is not currently in a position to invest in the development of new products, and needs to stabilise somewhat before this avenue is pursued.

Camel

Introduction

Like emus, the camel can be used for meat, leather and oil production. Camel meat is similar to beef when animals are slaughtered at the correct age and weight (Tandon *et al* 1988, Al-Sheddy *et al* 1999). Live camels have recently been exported to Malaysia, with the possibility of exports to Indonesia (press release). The Central Australian Camel Industry Association reports there has been some acceptance of camel meat into the restaurant and supermarket sectors in Australia (press release), with the potential for this industry to increase the acceptance of camel meat into Australian cuisine. The industry could also tap into export markets already opened for the live camel trade, and the as yet untapped export meat markets, such as the Philipines and Hong Kong (press release).

Processing practices

The need for export licensed abattoirs willing to process the currently small number of camels must be rectified if this meat industry is to expand. Part of this problem stems from the sanitation procedures required in multi-species abattoirs. Animals are presently processed in a domestic abattoir at Strathalbyn, South Australia or previously in Katherine, Northern Territory (http://www.nccnsw.organism.au/member/tsn/projects/NT/cacia.html). There is no specific standard for the production of camel carcasses and it would therefore be covered by the general Australian Standard for the Hygienic Production of Meat for Human Consumption

Although only small numbers of camels are processed for meat, AUS-MEAT has produced a manual developed in conjunction with the Central Australian Camel Industry Association Inc. with specifications for primal cuts and language for camel meat (Anon., 1998b) which at least standardises boning procedure for this species.

Shelf life status

Al-Sheddy *et al* (1999) showed camel meat that had been frozen and subsequently thawed, under experimental conditions, could be stored at 4°C for 7 days until product was considered to have reached spoilage. The estimated shelf life of product would have to be validated in a commercial situation and under Australian conditions, as 7 days is a long shelf life for meat stored aerobically and is not usually required by retailers. Zegeye (1999) evaluated the acceptability of camel meat that had been salted or smoked and salted in a community normally consuming camel meat. The results of this work were favourable, so there is the possibility of using this raw product for the manufacture of smallgoods as has been done for ostrich and kangaroo meat. However, the introduction of such products into a community which does not normally consume camel meat and meat products, and produced under commercial rather than experimental conditions should be done with caution. There needs to be particular attention paid to the validation of microbiological safety and shelf life.

Summary

The camel meat industry is not well developed at this stage, in terms of numbers of production animals and the limitation of available abattoirs in which the animals can be processed. Meat production is not the priority of this industry and, until the industry becomes more focussed on meat production, it is not feasible to undertake shelf life validation on limited meat products which may not yet have a domestic, let alone, an export market.

Buffalo

Introduction

The buffalo industry is well established in the Northern Territory, and has the potential to spread to south eastern states and southern Western Australia. Water buffalo are farmed in all states except Queensland, which does not permit the farming or slaughter of these animals (Lemecke). Most of the Northern Territory's buffaloes are exported live to Brunei, with approximately 12% of the animals in the NT supplying the local market and approximately 30% destined for export meat markets (Lemecke)

Processing practices

Buffaloes are slaughtered in abattoirs by service kill using electrical stimulation of carcasses (Agnote J32). There is no national standard for the production of buffalo carcasses and so would be covered by the general Australian Standard for the Hygienic Production of Meat for Human Consumption. There are however, abattoir procedures specified for the TenderBuff® brand marketed in Australia (Agnote J45).

Shelf life status

TenderBuff® guidelines (Agnote J32) recommend production of vacuum packaged boned product, stating that it can be stored for 12 weeks at 0°C, while 6 weeks can be achieved at 5°C. Such storage times are possible and have been achieved for beef and lamb, however, processors should be wary of designating shelf life specifications to their product without having conducted microbiological shelf life trials and assessing product organoleptically. In the carcass specifications for TenderBuff® (Agnote J32) post slaughter treatments recommend 2 weeks ageing of primal in vacuum packaging under refrigeration, which will reduce the potential shelf life of the primal cuts in the retail sector.

A limited shelf life trial on vacuum packaged buffalo primal (10 days at an unspecified temperature) and buffalo mince (7 days at an unspecified temperature and packaging conditions) was undertaken as part of a RIRDC funded project (Leach, 2001). The primal cut was examined on the day of production, 1 week following production, and 10 days post production for total viable count (TVC) at 5°C and 25°C and for the spoilage organism *Pseudomonas*. Mince was examined on the day of production and 1 week following production, for the tests outlined above. The primal cut was acceptable organoleptically until day 7, however, the spoilage organism was at relatively high numbers by this stage (1.6×10^4 cfu/g) and the product was unacceptable organoleptically by day 10 though the *Pseudomonas* count had decreased (3.0×10^3 cfu/g). The mince showed a decrease in *Pseudomonas* organisms from day 0 to day 7. That is unexpected, as the odour of the product was considered unacceptable at day 7 and the product was therefore undergoing spoilage. *Pseudomonas* breaks down meat proteins through enzymatic activity resulting in the production of putrefactive odours as this organism approaches spoilage levels. Both meat products had very high total bacteria count at the start of the trial, which is usually indicative of poor hygiene at some point along the processing line, and is the only conclusion to be drawn as only TVC and *Pseudomonas* were performed on the product.

In a review by Anjaneyulu *et al* (1988) the authors concluded "the shelf life of buffalo meat is comparable to that of beef". Diced and minced meat could be stored at 4-6°C for a week, retail cuts were stored at 4.4°C for 5 days, frozen vacuum packaged loin cuts and mince were acceptable for 6 months (Anjaneyulu *et al* 1988). In later studies of Indian buffalo processing, in what was described as modern facilities, the total bacterial counts were reasonably low (Yashoda *et al* 2000, Ramasastry *et al* 1999, Sachindra *et al* 1998). Yashoda *et al* (2000) found meat cuts from the shoulder and leg, stored aerobically were acceptable at 7 days, while minced meat was acceptable for almost 5 days. The total microbial counts taken from various sites on the buffalo carcass ranged from 3.21-4.04 $\log_{10}/cm^2$, which would fall into the 'good' category as set by the SCARM Meat Standards Committee (Anon., 1998a). It should be noted that none of the sites sampled in this study equate to those recommended by export or domestic regulations in Australia for beef carcasses, namely the rump, flank and brisket, which are pooled as composite samples rather than as individual sites. Gill *et al* (2000) found the total aerobic count per cm^2 detected from buffalo carcasses to be approximately $\log_{10}$ 2.46, which falls into the excellent category according to the SCARM Meat Standards Committee (Anon., 1998a). It should be noted that the abattoir involved in the study was a small research abattoir, not operating under commercial conditions, therefore monitoring counts on carcasses are likely to be higher in a commercial operation.

Limited work is published on the microbiology of buffalo meat smallgoods. Buffalo meat is suitable for use in various processed products such as sausages, corned meat and salami (Anjaneyulu *et al* 1988). Mesophilic bacterial counts performed on minced buffalo meat, the principle starting ingredient in smallgoods production, were high on the day of mincing as reported by Kanatt *et al* (1997). In this study the buffalo mince, was stored between 0-3°C and was considered microbiologically unacceptable by week 2 of storage (Kanatt *et al* 1997). Sahoo and Anjaneyulu (1997) examined aerobic and vacuum packaging of buffalo meat nuggets with and without the incorporation of the natural antioxidants sodium ascorbate, α-tocopherol acetate and sodium tripolyphosphate. The vacuum packaging "improved the quality of nuggets" while the aerobically stored nuggets with incorporated antioxidants achieved a shelf life of 30 days, compared to only 10 days for the nuggets not containing antioxidants (Sahoo and Anjaneyulu 1997).

Summary

The buffalo industry is well advanced compared to the other new and emerging meat species in terms of the standard of meat production; the marketing of buffalo meat on the domestic market with the registration of the TenderBuff® brand; and more published data on the microbiological analysis of buffalo carcasses and meat. Further microbiological evaluation of buffalo carcasses, boned meat and smallgoods in Australia would be beneficial to the industry, however such studies in this situation are better undertaken with individual processors rather than on an industry wide basis.

Crocodile

Introduction

The crocodile industry as a whole is heavily regulated by both state and federal agencies. Examples of the regulations which may govern a crocodile farm (depending on the type of business) for the state of Queensland include: Nature Conservation Act, Environment Protection Act, Code of Practice-Crocodile Farming, Code of Practice-Minimum Standards for Exhibiting Wildlife in Queensland, Wildlife Protection Act, Export Food (Processed) Orders, Meat Industry Act, SCARM Report 67. Australian Standard for the Hygienic Production of Crocodile Meat for Human Consumption, Workplace Health & Safety Act, Guide to Crocodile Safety. These regulations will vary somewhat for each state, though the federal regulations apply to all states.

Processing practices

Crocodile meat in Australia is harvested from the saltwater crocodile (*Crocodylus porosus*) (Millan *et al* 1997). These animals are either farmed or ranched (depending on the state), they usually harvested at 2-3 years at which age the animals have reached more than 1 metre in length. Approximately 5 kilos of meat can be derived from animals this size (http://www.aph.gov.au/senate/committee/rrat_ctte/wild/WLChap11.htm).

Four abattoirs are accredited for processing crocodiles in Australia (http://www.aph.gov.au/senate/committee/rrat_ctte/wild/WLChap11.htm). Slaughter is fairly labour intensive as "one worker can process between eight and ten crocodiles per day" and most of the meat produced is sold on the domestic market (http://www.rirdc.gov.au/champions/LagoonCrocodileFarm.html, http://www.NT.gov.au/dpif/pastoral/meatlive/3crocs.html). Animals selected for slaughter are either moved to a holding pen or are destroyed in the pen. Crocodiles are slaughtered by a bullet to the top of the head, the animal is then exsanguinated by severing the main artery and spinal cord. Exposed sites are cleaned/sanitised. Post exsanguination, the entire carcass is sanitised, and is hung by the tail overnight under refrigeration with the cloaca plugged. On the day of further processing the carcass is again sanitised. The head of the carcass is covered with a plastic bag and is skinned on a table. The skin is the first consideration of the process, meat is of secondary importance (Peucker). Carcasses are rarely eviscerated. This increases the likelihood of contamination of meat with ingesta (Millan *et al* 1997). Boned meat is dipped in either acetic acid or chlorine wash as a decontamination step (Millan *et al* 1997), after which meat is stored frozen prior to sale (http://www.hartleyscreek.com/how-time-works.htm). It should be noted that routine dipping of meat in organic acids is not permitted in some export markets, such as Singapore, because of the belief that this may only act as a bacterostatic agent on meat, not killing bacteria but merely suppressing them. There is also the belief that applying the acid to meat may select for acid tolerant bacteria such as *Lactobacillus* spp. which cause spoilage of meat in vacuum package meat or more seriously, acid resistant pathogens. A further cause for concern is that acid washes are seen as a "clean up" step for poorly processed meat.

Crocodile meat cuts have been developed, though not yet standardised by AUS-MEAT. They include: bone in upper carcass, bone in tail, satay, neck chop, boneless meat from the leg, chest and abdomen, striploin, tail fillet, tenderloin, bone in leg, T-bones, spare ribs, racks (not frenched). Other crocodile meat products available include smoked product, smallgoods and bones.

Shelf life status

"Reptiles may be considered a natural reservoir for *Salmonella*" (Madsen, 1996), and as such there is the potential foodborne risk from crocodile meat. *Salmonella* isolations are not uncommon (Millan *et al* 1997), and serotypes associated with human disease with have been isolated from crocodiles in Australia (Manolis *et al* 1991, Rickard *et al* 1995). Huchzermeyer (1997) warns of several public health risks associated with processing crocodile meat in South Africa ranging from viral, bacterial and parasitic agents to antimicrobial residues, though most of those listed were considered unlikely to cause problems in humans. However, *Salmonella* is a real risk and ongoing monitoring for this pathogen recommended. The possible foodborne pathogen *Aeromonas hydrophila* has also been isolated from crocodile meat (Madsen 1996). In this study 90% of the meat samples were contaminated with this organism.

The risk of contamination of crocodile meat during processing is heightened compared to other meats because the skin is well attached to the meat making it quite difficult to remove and so underlying meat is can be readily contaminated with skin. In addition, the primary product is skin and the processing steps are aligned with maintaining skin value rather than assuring food safety. To ensure the safety of crocodile meat for the consumer, regular testing of product for enteric bacteria, specifically *E.coli* and *Salmonella* is necessary and acceptable limits for these organisms should be set.

During production, farmers chlorinate pond water to reduce the skin infections animals may acquire from water held at temperatures of 30 - 32°C. Concrete pens are preferred to dust floored pens and care is taken to ensure that concrete is smooth so as to reduce the amount of cuts and abrasions to the belly of the animals and for ease of cleaning of pens (http://www.rirdc.gov.au/champions/LagoonCrocodileFarm.html, Peucker).

Madsen *et al* (1992) reported extremely low bacterial counts (2-50 cfu/cm^2) on crocodile meat slaughtered in Zimbabwe where the tail meat processed in this study had been dipped in 30 ppm chlorine solution. In a later study the same author found aerobic plate counts ranging from 3.49-6.48 $\log_{10}$ cfu/g (Madsen, 1996). Oblinger *et al* (1981) found higher bacterial counts of 2.88-3.02 $\log_{10}$ cfu/gram from alligator meat immediately post slaughter, reaching counts of 8.32-8.59 $\log_{10}$ cfu/gram after 15 days refrigerated storage. Rickard *et al* (1995) found bacterial counts from Australian processed crocodiles in the order of 2 $\log_{10}$ cfu/cm^2. These results are promising for the Australian product, but only give limited information on the microbiological status of the meat in terms of pathogenic and spoilage bacteria and no indication given of the potential shelf life of crocodile meat.

Crocodile terrine (combined with ostrich) can be stored unopened under refrigeration for 28 days and can be frozen for up to 6 months though product must be used within 4-5 days of thawing, as recommended by the Australian Ostrich Association website (http://www.aoa.asn.au/information/meat/meat.html). It is unclear as to how this shelf life was determined, and microbiological validation of this estimate should be carried out.

Summary

Given the risk of contamination of crocodile meat with *Salmonella* the development of adequate HACCP plans for the industry seems essential. However, the industry is largely focussed on the production of crocodile skins, the profit from which far outweighs that obtained from meat, and is thus highly unlikely to change in the future. Until the crocodile meat industry expands, the development of HACCP plans is probably best left to the individual processors, in response to requirements for export licensing.

Rabbit

Introduction

There is an established rabbit farming industry in NSW, Victoria and Western Australia. The rabbit meat industry is growing with approximately 300 new licenses have been issued in NSW in the past few years (Eady, 2000). Australia annually produces 106 tonnes of rabbit meat which equates to around $800,000 wholesale. This is based on an established domestic market demand and marketing system. The industry is focussed on servicing the domestic market for rabbit meat (RIRDC Project Report: ABA-7A), which is largely made up of the food service sector. However, there is potential to expand into the European and Chinese export markets provided the industry can guarantee supply to meet the demand.

Processing practices

Comparatively small numbers of rabbits are processed in Victoria at only a few abattoirs. The abattoirs are governed by the Australian Standard for the Hygienic Production of Rabbit Meat for Human Consumption. In other regulatory frameworks, there are recommendations for processing practices."The EU council directive allows rabbits to be suspended for slaughter provided that appropriate measures are taken to ensure that they are in a sufficiently relaxed state for stunning" (Lambooij *et al* 1999b). Minimal current for electrical stunning of rabbits is 300mA (Lambooij *et al* 1999a).

Limited value added products are available for rabbit, namely smoked or canned products, sausage and burgers; most of the meat is in the form of whole carcasses or pieces.

Shelf life status

Some companies are claiming extraordinary shelf life for their vacuum packaged product without the need for refrigeration. No literature could be found to substantiate such claims, and I would caution companies in making such rash claims which could potentially damage the entire industry, nationally and internationally, if products cannot stand up to customer expectations.

Khalafalla (1993) reported quite low bacterial counts (for mesophilic and psychrophilic plate counts, Enterobacteriaceae, *Pseudomonas, Staphylococcus*) for freshly slaughtered rabbits in Egypt. This is encouraging if the Australian situation is similar, as given the correct handling and storage conditions it is possible to obtain a reasonable shelf life from product with such low initial counts. This study did not detect the pathogens *Yersinia enterocolitica* or *Listeria monocytogenes.* The former is normally associated with pigs as it resides in the tonsils of these animals so this

finding is not unexpected and the absence of the latter may reflect good processing practices. *Salmonella* Typhimurium was detected from a small percentage of the carcasses tested (5%), however other serovars may have been present which were not tested for and may have increased the overall incidence of *Salmonella* in this study. Khalafalla (1993) also studied rabbit meat from retail outlets as did Pérez Chabela *et al* (1999) in Mexican retail outlets. Both these studies reported higher counts for the organisms listed above than those reported for freshly slaughtered carcasses. This is expected as there has been opportunity in the handling and storage post slaughter, for increase in bacterial numbers. Pérez Chabela *et al* (1999) tested meat at up to 14 days of storage at 4°C, however, only reported their findings in terms of the Mexican legal requirements of 5 days retail shelf life. Given this it should be possible for Australian rabbit meat to achieve at least 5 days retail storage.

Summary

The rapid expansion of the rabbit meat industry increases the throughput demand on abattoirs currently servicing the industry, and may pave the way for other abattoirs to be commissioned. The need to develop microbiologically sound HACCP plans for this industry is vital to ensure that the established domestic market is maintained and possibly expanded, and to help build documented evidence for the quality of Australian rabbit meat for entry into potential export markets. Not only does meat need to be safe but must have adequate shelf life to meet expectations in the marketplace.

Kangaroo

Introduction

The Australian kangaroo industry has long been established, particularly in the production of skins/leather and meat for both pet food and human consumption. The export of kangaroo products to the USA has suffered in the past because of the misinformed view that endangered species of macropods were culled. Other misinformation about kangaroo meat is that the two parasitic worms carried by the animals are detrimental to human health. This is not the case: their presence only affects the aesthetic appeal of the meat to the consumer (http://www.parliament.vic.gov.au/enrc/unff/report/uti.4-07.htm). Research commissioned by RIRDC highlighted the need for increased consumer knowledge and information on the benefits and versatility of kangaroo meat for human consumption, in short an improved marketing campaign (Purtell, 1997).

Processing practices

Kangaroos are considered as game because they are killed in their natural habitat (Sales and Dingle, 1998). According to regulations the time, date and place of shooting must be documented (Sales and Dingle, 1998). The animal is bled, partially eviscerated and the tail and feet removed in the field (Sales and Dingle, 1998). The carcass must be refrigerated within 2 hours of shooting if shot between sunrise and sunset, and must reach a deep muscle temperature of 7°C within 12 hours before being transported to the processing plant (Sales and Dingle, 1998). The processing of kangaroo meat is governed by the Australian Standard for the Hygienic Production of Farmed Macropod Meat for Human Consumption. AUS-MEAT has produced a manual developed on behalf of the Kangaroo Industry Association Australia for kangaroo meat products (Anon. 1998b). The kangaroo meat cuts detailed are: rack (frenched), leg rump-on bone-in, leg rump-on boneless, leg rump-on/shank-off boneless, leg rump-off/shank-off boneless, tenderloin (fillet), leg cuts, tail butt, tail slices, shank bone-in, loin set (striploin denuded, loin fillet denuded, long fillet denuded), and saddle bone-in (8 ribs). Smallgoods produced from kangaroo meat include patties/rissoles, ravioli, sausages, smoked hams, proscuitto, jerky, corned meat, terrines, galantines, pate, crumbed cutlets (Anon, 1998c).

Shelf life status

There is limited data on the shelf life of kangaroo meat, and on microbiological examination of this meat in general. A study of 81 kangaroo carcasses by Bensink *et al* (1991) revealed 11% of these carcasses were contaminated with *Salmonella*, with an average coliform count of 3.54 $\log_{10}$/g. Guidelines for Microbiological Testing of Game Meat in Game Meat Establishments (AQIS notice Meat 99/09) "applies to export standard kangaroo meat produced at Wild Game Meat establishments" and ensures on-going testing of *E.coli* and *Salmonella* with the ultimate aim to continually improve the microbiological quality of kangaroo carcasses with respect to these two organisms.

Summary

The kangaroo industry has well established domestic and export markets for leather and meat. The industry has survived the bad publicity image of our national emblem being shot as a pest, and would appear well equipped to flourish in the face of adversity. There is little published data on the microbiological status of kangaroo carcasses in terms of both spoilage and pathogenic bacteria. However, the implementation of microbiological monitoring of this species, regulated by AQIS, establishes a national database on the progress of this species with respect to pathogen reduction on carcasses. Individual plants that have not already done so would benefit from the microbiological assessment of their products for safety and shelf life to ensure the reliability of their product in the domestic and export marketplace.

Conclusion

The RIRDC New Animal Products Research Manager suggested ostrich meat as a favourable option for the introduction of generic HACCP plans. This industry has an extensive range of meat products already developed and marketed, and has access to numerous export markets. The fear is that many of these products have arbitrarily assigned shelf lives, and validation of these would benefit not only single companies but also the industry as a whole. Development of generic HACCP plans, which still need to be modified for individual processors, can assist in the establishment of quality assurance programs which are regulatory requirements for the domestic and export meat works.

The emu industry has been experiencing a down turn in profitability in recent years and this industry would benefit more at this stage from increase in marketing of meat and meat products. Although support for this project has been expressed by the Emu Producers Association of Victoria, their priority was to increase the profitability of skin production rather than increase the microbiological quality of emu meat. It is unlikely that this species will be selected for the development of generic HACCP plans. However, this industry has some interesting issues which need to be addressed in terms of meat quality and microbiology. The Victorian association is interested in reducing the stress levels of birds currently being transported to abattoirs or, alternatively, killing birds on farm. This would impact on current processing practices as operations would have to demonstrate to regulatory bodies that this practice would not prove detrimental to the microbiological quality of the ultimate carcass.

The camel industry will eventually benefit from microbiological investigation of camel meat products, as the majority of the published research in this area has been conducted overseas. Because of the small number of camels currently processed in Australia and the lack of dedicated abattoirs for this species, it is probably best to focus the activities of this project on another species. This stance may be reversed if and when the camel meat industry becomes more established with a strong domestic market and has vision to turn to exporting meat and meat products.

Recent research commissioned by RIRDC on "Maximising Marketing Opportunities for Buffalo Products" included a small shelf life trial on primal cuts and buffalo sausage. Coupled with the specifications outlined by TenderBuff® in the Northern Territory, the buffalo industry is already well placed for production of quality meat and meat products and has not been selected for further research in this project.

The crocodile industry is focussed on the production of skin from these animals because of the lucrative returns. Meat, therefore, is a secondary by-product of the skinning process. The number of animals processed for meat is quite low compared to other industries, and, although further research into this meat industry would be interesting, the volume of product is still low and both domestic and export markets need to be expanded. However, the ongoing concern with the association of crocodile meat with the foodborne pathogen *Salmonella* may still warrant considering this industry for the production of generic HACCP plans.

The RIRDC New Animal Products Research Manager also suggested the rabbit industry as a favourable option for the introduction of generic HACCP plans. This meat industry has expanded in recent years, probably due to the eradication

programs of wild rabbits, and has an established domestic market with the potential to expand to the export arena.

The kangaroo industry is well established both for the production of skins and leather, and meat for both pet food and human consumption. The use of this animal as a meat production animal has suffered because of images of Australia's coat of arms being hunted and shot. However, the industry has established export markets and has identified domestic marketing areas which can be improved to increase consumption. The industry has a microbiological monitoring program already in place for export licensed processing plants which are regulated by AQIS. This species has not been chosen for the development of generic HACCP plans.

For these reasons, the species selected for the development of generic HACCP plans are ostrich and rabbit.

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Attachment 1:

Industry Questionnaire to Review Current Processing Practices for Various New and Emerging Meat Species

Introductory remarks

Joanne Bobbitt, Senior Scientist, Food Microbiology Department VIAS.

Funded by RIRDC and NRE to undertake a review of current processing practices ….

Questionnaire to take about 30 minutes of your time.

My background is in the pork processing industry, and the beef and lamb industries.

Have developed generic HACCP plans for export offal lines for the pork industry.

Questionnaire

1. Is your company an abattoir or a boning room, a mixture of the two, further processing or packaging plant?
2. Is your company an export or domestic licensed works (MSEP or not)?
3. What are the regulatory requirements that govern your operation?
4. Do you process a single species or is the plant licensed for mixed species production?
5. Which markets do you supply?
6. What is an average size kill for your works?
7. What proportion of your average days kill/boning is made up of non-farmed animals?
   If any non-farmed animals are slaughter/boned, how/where are these animals culled?
   Are they transported live to abattoir?
   Are they culled prior to transport ie in the field?
   If culled prior to transport, how are the bodies transported to the abattoir (refrigeration)? Is the any QA covering this aspect of the operation?
   What is the approximate time from cull to processing?
8. For farmed animals, what is the average holding time at the farm prior to transportation?
   Are the animals off feed and water prior to transport? If so, for how long?
   Transport distance/time?
   Lairage at abattoir?
   Are animals cleaned prior to slaughter?
9. How are the animals stunned? Exsanguinated?

10. Can you detail the steps along the processing chain of your facility (process flow chart)?
11. Are there any 'hot' steps like scald tanks in your process? If so at what temperature are these steps?
12. What is the average time taken from animal/body entering slaughter line to entering chiller?
13. What temperature is the processing environment?
14. What is the minimum time spent in chiller before load out/further processing?
15. Do you monitor the time and temperature of your product once it leaves your facility, or is this the responsibility your clients?
16. Do you have current a HACCP plan?
    Was this written by people within the company or by an external consultant?
    What CCPs are identified in your plan and how did you identify them? How do you monitor them and how often?
17. Do you routinely carry out microbiological testing on your carcasses/boned product?
    If so, do you carry this out yourself or do you contract a laboratory to do this?
    What tests are performed? Do you trend the data?
    Have you ever had you product tested microbiologically, either by contracting a laboratory or by involvement in a research project?
18. What is the shelf life of your product? How was this determined? Is this reviewed when changes to the process occur?
19. Would you be interested in participating in a RIRDC funded microbiological study that would be used as the basis for a industry wide generic HACCP plan? Your participation in this project would result in you having a HACCP plan of your own.
20. Do you think the industry would benefit from the development of generic HACCP plans, which would be adapted to suit individual plants? (If the response is no - need to contact further plants in the same industry, through consultation with appropriate industry body)
21. Would it be possible visit your facility?
22. Are you interested in expanding/further exploring value adding your product as part of a separate RIRDC funded project?

Thank you for your time and cooperation

Appendix 2:

Foodborne pathogenic bacteria of concern in the production of ostrich and rabbit for human consumption

Clostridium perfringens

Habitat / origin

Clostridium are endospore-forming anaerobic organisms which are widely found in soil and in the intestinal tracts of humans and domesticated animals. *C.perfringens* is aerotolerant and is associated with human food-borne diseases.

Importance in food

Food poisoning from *C.perfringens* occurs after ingestion of large numbers of viable bacteria in cooked foods. Sporulating cells produce heat-labile entertoxins which are released in the intestine and induce the major symptoms of diarrhoea and vomiting.

Spores of different strains of *C.perfringens* may withstand different temperatures. Some are able to tolerate 100^0C for several hours, while others are destroyed within a few minutes. In most environments, heat-sensitive strains outnumber heat-resistant strains. Most food poisoning outbreaks from *C.perfringens* are linked to the heat-resistant spores. However, recent evidence now shows that heat-sensitive strains also cause food poisoning.

Growth and survival characteristics

The optimum growth temperature occurs at about 43-47^0C and the maximum being slightly over 50^0C, a few strains are able to grow at 6^0C. *Clostridium perfringens* has a short generation time in warm conditions, less than 10 minutes. Meat products may contain spores which survive high temperatures but may form vegetative bacteria when cooled. Vegetative cells are sensitive to freezing and are killed above 70^0C. The toxin is inactivated between 59-65^oC.

The minimum pH is 5.8 and the optimum is 7.2. The water activity (a_w) limit for growth is approximately 0.96.

Prevention and control

Cooking and cooling can both be used for the control of *C.perfringens*. Cooling the product rapidly through the temperature ranges 55-65^0C and reheating to above 70^0C immediately before consumption of the product.

Staphylococcus aureus

Habitat / origin

Staphylococcus aureus is ubiquitous in the environment, commonly found on meat and meat products, including hides, feathers and skin and in warm-blooded animals, including humans.

Importance in food

S. aureus colonises the skin, mouth, and nasal passages, often contaminating the hands and then food. Fifty percent of *S. aureus* strains produce a heat-resistant enterotoxin. Staphylococcal food poisoning is caused by the ingestion of toxin produced by large numbers of *S.aureus* allowed to multiply in food.

Growth and survival characteristics

The potential for production of enterotoxin is greater in foods exposed to temperatures that permit the growth of *S.aureus*. The organism grows well in air, and has an optimum growth temperature of 37^0C, but can grow at temperatures as low as 10^0C. It can tolerate low water activity (a_w) and high salt concentration (up to 10%). The factors affecting toxin production are pH (inhibited below pH 5), temperature, with poor toxin production under anaerobic conditions.

The organism is resistant to freezing and thawing. The toxin is stable in frozen storage.

Prevention and control

Methods to prevent Staphylococcal food poisoning are based on good manufacturing practices which limit the degree of contamination which prevents the production of toxins in foods. Personal hygiene of food handlers is important.

Yersinia enterocolitica

Habitat / origin

Human and animal pathogenic strains of *Y. enterocolitica* have been recovered mostly from raw pork tongue and raw pork mince, although non-pathogenic strains of *Y. enterocolitica* have been recovered from a variety of other foods. The major reservoir for *Y.enterocolitica* is the live pig.

Importance in food

Yersinia are psychrotrophic organisms they are extremely important in the food industry because of their ability to multiply in foods during refrigeration storage and to persist in refrigerated areas of processing plants.

Growth and survival characteristics

Reports have shown that *Y. enterocolitica* can grow over a wide range of temperatures, with an optimum temperature of 34^0C. They are sensitive to heat and to irradiation, but survive freezing. *Yersinia enterocolitica* can multiply over a wide pH range from 4.6-9.0, with the optimum at pH 7.0-8.0.

Salt tolerance is moderate, surviving in 5%-6% salt, growing with 5% salt under refrigeration temperatures.

Prevention and control

To reduce the incidence, and probably the initial concentration of *Y.enterocolitica* in raw pork certain modification steps in slaughtering are necessary when removing intestines, excising the tongue and deboning the head meat.

An effective way of preventing Yersiniosis is to educate people in proper handling of raw pork when preparing food in food-service establishments and at home. *Yersinia* are very heat sensitive and should be destroyed by heat processes such as pasteurisation unless initial numbers are high. *Yersinia enterocolitica* is becoming increasingly recognised as a cause of diarrhoeal disease in man.

Salmonella spp.

Habitat / origin

Almost all members of the *Salmonella* genus are potentially pathogenic. *Salmonella* spp are common inhabitants of the intestinal tracts of many animals, especially cattle and poultry, and during slaughter and dressing processes, they can easily contaminate food via faecal contamination.

Importance in food

Food borne Salmonellosis is one of the major causes of human gastroenteritis.

Growth and survival characteristics

The optimum growth temperature for *Salmonella* spp is approximately 37^0C and they can grow from about pH 4.0-9.0. They can reproduce in the absence of oxygen.

Prevention and control

The occurrence of *Salmonella* on meat cannot be entirely prevented by the application of good hygienic practices in the slaughter chain. However, it does minimise the rate of any further contamination.

Chilling is important as no growth occurs below 7^0C. If heating is applied to raw meat, there is a high chance of killing *Salmonella* as they are sensitive to heat (above 60^0C). Rapid freezing promotes survival of *Salmonella.*

Enterohaemorrhagic *Escherichia coli* (EHEC)

Habitat / origin

Most Enterohaemorrhagic *Escherichia coli* (EHEC) will be transferred to meat from the faeces of the dead animal. Any HACCP type program which limits faecal contamination of carcasses on the kill floor will reduce the numbers of those bacteria on carcasses and on the meat from those carcasses.

Importance in food

Enterohaemorrhagic serotypes of *Escherichia coli* were recognised relatively recently as food-borne pathogens. Serotype O157 has been associated with large outbreaks in North America, Europe and Japan. In Australia, serotypes O111 and O126 are among a large group of serotypes of concern rather than O157.

EHECs are commonly associated with haemorrhagic colitis, haemolytic uraemic syndrome in children and thrombotic thrombocytopenic purpura in adults. Both of these conditions are a result of toxin production by the bacterium in the host. The infective dose for EHECs may be as few as 10 cells.

Growth and survival characteristics

Most of the studies on growth characteristics for EHECs have been performed on O157. The range of growth temperatures is from 7^{o}C for some strains to 46^{o}C for others. The optimum range is 35-40^{o}C. Pathogenic *E. coli* can survive in foods at refrigeration temperatures (3-7^{o}C) with little reduction in numbers over 1-5 weeks. *E. coli* O157 can grow at pH 4.5 in some foods. The maximum pH for growth is 9.0 and optimum 6-7. They are also capable of growth in 6% NaCl. EHECs will tolerate water activity of 0.995 down to 0.95

Prevention and control

Foods should be cooked to the correct temperature (more than 60^{o}C) to kill the organism. O157 is more sensitive to heat than *Salmonella* and therefore temperatures capable of killing Salmonella should also kill O157. Care must be taken to avoid re-contamination post-cooking.

Aeromonas spp.

Habitat / origin

Aeromonas spp. are usually isolated from aquatic environments and animals associated with those environments, such as fish, leeches and frogs. These organisms can be part of the normal intestinal flora of food animals such as pigs, cattle, sheep and poultry. It is possible for these organisms to be introduced into foods from water, animal faeces or food handlers.

Importance in food

Aeromonas spp. have been associated with foodborne outbreaks and with spoilage of foodstuffs as they are able to grow rapidly at refrigeration temperatures and under modified atmosphere conditions.

Aeromonas veronii boivar sobria has been found in Australian raw meat and meat products, offal and poultry. This organism can cause gastroenteritis, wound infections and septicaemia. The infectious dose of this organism is not known.

Species of *Aeromonas* can cause spoilage of aerobically stored or vacuum packaged fresh meat by the production of hydrogen sulphide which turns the product green.

Growth and survival characteristics

Aeromonas has optimal growth temperatures from 28-35^{o}C, and can grow at temperatures as low as 0°C and as high as 45°C. At 28°C most strains of *Aeromonas* can grow at pH 5.5, however, at temperature around 5°C these organisms cannot grow at this pH and not at pH 6.5. These organisms can grow in modified atmosphere storage where there is increased concentration of CO_2, particularly at 10-36%. This organism can grow under vacuum on meat.

Prevention and control

These organisms are killed at temperatures as low as 45°C (depending on the substrate). They are susceptible to irradiation. Commercial disinfectants and chlorine should be effective against this organism provided such chemicals are not inactivated by organic matter.

Campylobacter spp.

Habitat / origin

Campylobacter jejuni and *C. coli* can be isolated from a wide variety of wild and domestic animals. *Campylobacter jejuni* incidence in beef and sheep can be as high as 50%, while *C. coli* is the dominant species in pigs. These organisms can be present in up to 100% of birds in poultry flocks. As these organisms are of faecal origin, water can become contaminated with them. Poultry is by and large the greatest potential source of *C. jejuni* for humans. Red meat carcasses are also a source of campylobacters, but less so after the chilling process.

Importance in food

Besides fresh meat and poultry, campylobacters have been isolated from milk and eggs.

Growth and survival characteristics

The optimal growth temperature for *Campylobacter* is 42-43°C. *Campylobacter jejuni* survives better in food at ambient temperature than at refrigeration temperatures. This organism is also susceptible to temperatures above 55°C. It can be inactivated by UV and gamma irradiation. The optimal pH for this organism is 6.5-7.5, with death occurring at pH below 4.0.

Prevention and control

Care with the removal of viscera, as offal can harbour these organisms, to avoid contaminating carcass surfaces. Drying of carcasses can help reduce the survival of campylobacters contaminating surfaces.

Foods should be cooked to the correct temperature (55-60^{o}C) to kill these organisms. Care must be taken to avoid cross contamination by transfer of the organism from raw meat to ready-to-eat foods.

Listeria monocytogenes

Habitat / origin

Listeria monocytogenes has been isolated from a variety of habitats including soil, sewerage, silage , food processing environments, raw meats and healthy human and animal faeces. In meat processing facilities the areas that are considered the most important in terms of isolating *Listeria monocytogenes* are chilled storage, packaging areas and transport.

Importance in food

Foodborne disease outbreaks of this organism have been associated with raw milk and dairy products such as ice cream and soft and surface ripened cheeses, paté, seafood and vegetables.

The presence of this pathogen on raw foods is likely to be unavoidable.

Growth and survival characteristics

Listeria monocytogenes is able to survive freezing temperatures of -18°C for several weeks in various food substrates. The organism is also able to survive the refrigeration temperatures (<4°C) used to control many other pathogenic organisms of concern in the meat industry. The pH range this organism can grow at is pH 4.6 - 9.6. It can grow in aerobic, microaerophilic and anaerobic conditions and in the presence of CO_2. Therefore, *Listeria monocytogenes* can survive and grow in the modified atmosphere packages meat may be stored in.

Prevention and control

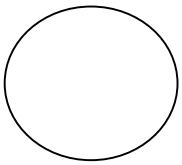
The thermal destruction of this organism, although possible, is difficult to ascertain. The organism is also difficult to control by chilling as it is capable of growth at below 4°C. This organism is ubiquitous and therefore it is unlikely that it will be totally eliminated from raw foods. However, the application of HACCP into processing plants, the use of "hurdle" technology, establish practical and useful monitoring plans and educate food industry personnel and the end consumer.

Appendix 3:
Generic HACCP plan for ostrich meat production

PRODUCT DESCRIPTION	Ostrich meat
INTENDED END USE	Export and domestic wholesale and retail markets as fresh product intended to be cooked
PRESERVATION METHOD	Chilling and vacuum packaging
PACKAGING	Vacuum packaged (oxygen impermeable plastic bags) primals, packed in new, cardboard cartons
IDENTIFICATION AND LABELLING	Full trade description
CONTROLS DURING STORAGE	Time/temperature to limit microbial growth during chilling process
CONTROLS DURING DISTRIBUTION	Time/temperature to limit microbial growth
SENSITIVE CONSUMER?	No - intended for general consumption
FINAL CUSTOMER PREPARATION	Intended to be cooked

Index of Symbols

Process



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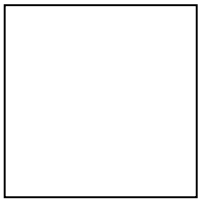

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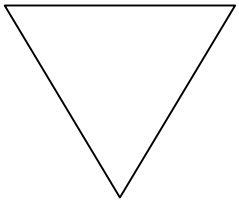
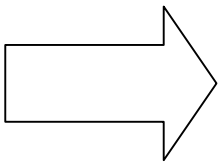
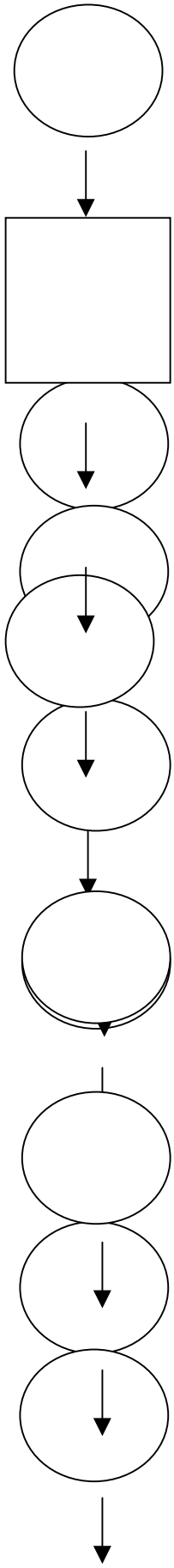


Transport

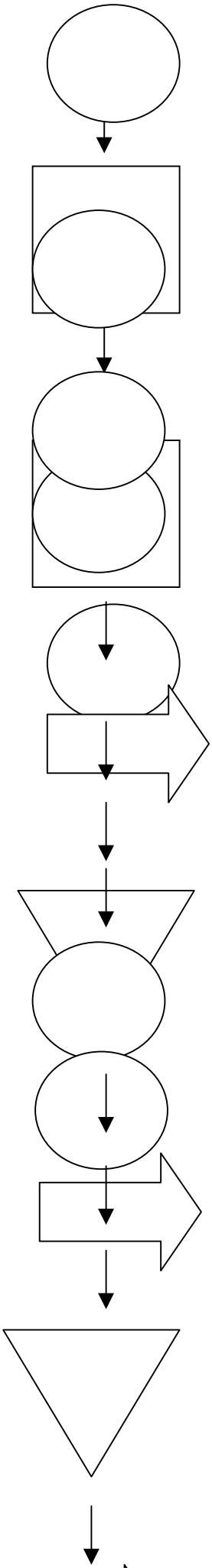


Ostrich Process Flow Chart

1. Receive birds
2. Ante mortem inspection
3. Restrain
4. Stun bird
5. Cut throat, heart stick
6. Break neck
7. Remove head
8. Pluck feathers
9. Remove legs
10. Skin
11. De-fat carcass

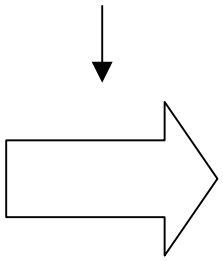


12. Eviscerate
13. Post-mortem inspection
14. Remove neck
15. Remove ribcage
16. Inspect and trim
17. Split carcass
18. Move to chiller
19. Chill
20. Trim/bone carcass
21. Pack
22. Move to chiller
23. Chill



24. Load out

25. Transport



Critical Control Point Determination: Ostrich Processing

Process step/ incoming material	Identify hazard (physical, chemical, biological) Does hazard occur at this step / in this incoming material? No: go to next hazard Yes: go to Q1	Q1 Do preventive measures exist for the identified hazard? No: not a CCP Yes: go to Q2	Q2 Does this step eliminate or reduce the likely occurrence of a hazard to an acceptable level? No: go to Q3 Yes: CCP	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels(s) No: not a CCP Yes: go to Q4	Q4 Will a subsequent step eliminate identified hazard(s) or reduce the likely occurrence to an acceptable level? No: CCP Yes: not a CCP	CCP number
1. Receive bird	None					
2. Ante mortem inspection	BIOLOGICAL Diseased birds possibly carrying a notifiable disease	No				
3. Restrain	None					
4. Stun bird	None					
5. Cut throat, heart stick	BIOLOGICAL Transfer of bacteria from feather/skin to carcass by	Yes	No	Yes	Yes	

	knife incision					
6. Break neck	None					
7. Remove head	None					
8. Pluck feathers	BIOLOGICAL Transfer of bacteria from feather/skin to carcass if skin damaged during plucking	Yes	No	Yes	Yes	
Process step/ incoming material	Identify hazard (physical, chemical, biological) Does hazard occur at this step / in this incoming material? No: go to next hazard Yes: go to Q1	Q1 Do preventive measures exist for the identified hazard? No: not a CCP Yes: go to Q2	Q2 Does this step eliminate or reduce the likely occurrence of a hazard to an acceptable level? No: go to Q3 Yes: CCP	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels(s) No: not a CCP Yes: go to Q4	Q4 Will a subsequent step eliminate identified hazard(s) or reduce the likely occurrence to an acceptable level? No: CCP Yes: not a CCP	CCP number
9. Remove legs	None					
10. Skin	BIOLOGICAL Transfer of bacteria from skin to carcass as skin is removed	Yes	No	Yes	Yes	
11. De-fat carcass	BIOLOGICAL	Yes	No	Yes	Yes	

	Transfer of bacteria from operators hands to carcass					
12. Eviscerate	BIOLOGICAL Contamination of carcass by bacteria from ruptured intestinal contents	Yes	No	Yes	Yes	
13. Post mortem inspection	BIOLOGICAL Diseased birds possibly carrying an exotic disease	No				
Process step/ incoming material	Identify hazard (physical, chemical, biological) Does hazard occur at this step / in this incoming material? No: go to next hazard Yes: go to Q1	Q1 Do preventive measures exist for the identified hazard? No: not a CCP Yes: go to Q2	Q2 Does this step eliminate or reduce the likely occurrence of a hazard to an acceptable level? No: go to Q3 Yes: CCP	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels(s) No: not a CCP Yes: go to Q4	Q4 Will a subsequent step eliminate identified hazard(s) or reduce the likely occurrence to an acceptable level? No: CCP Yes: not a CCP	CCP number
14. Remove neck	BIOLOGICAL Transfer of bacteria from operators hands to carcass	Yes	No	Yes	Yes	

15. Remove ribcage	BIOLOGICAL Transfer of bacteria from operators hands to carcass	Yes	No	Yes	Yes	
16. Inspect and trim carcass	BIOLOGICAL Transfer of bacteria from operators hands to carcass	Yes	No	Yes	Yes	
17. Split carcass	BIOLOGICAL Transfer of bacteria from operators hands to carcass	Yes	No	Yes	Yes	
18. Move to chiller	BIOLOGICAL Transfer of bacteria from operators hands to carcass	Yes	No	Yes	Yes	
Process step/ incoming material	Identify hazard (physical, chemical, biological) Does hazard occur at this step / in this incoming material? No: go to next hazard Yes: go to Q1	Q1 Do preventive measures exist for the identified hazard? No: not a CCP Yes: go to Q2	Q2 Does this step eliminate or reduce the likely occurrence of a hazard to an acceptable level? No: go to Q3 Yes: CCP	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels(s) No: not a CCP Yes: go to Q4	Q4 Will a subsequent step eliminate identified hazard(s) or reduce the likely occurrence to an acceptable level? No: CCP Yes: not a CCP	CCP number

19. Chill	BIOLOGICAL Growth of bacteria due to incorrect storage temperature and/or inadequate spacing of carcasses in the chiller	Yes	Yes			1
20. Trim/bone carcass	BIOLOGICAL Transfer of bacteria from operators hands and contact surfaces to meat	Yes	No	Yes	Yes	
21. Pack	BIOLOGICAL Transfer of bacteria from operators hands to meat PHYSICAL Microchips present in meat	Yes	No	Yes	Yes	
Process step/ incoming material	Identify hazard (physical, chemical, biological) Does hazard occur at this step / in this incoming material? No: go to next hazard Yes: go to Q1	Q1 Do preventive measures exist for the identified hazard? No: not a CCP Yes: go to Q2	Q2 Does this step eliminate or reduce the likely occurrence of a hazard to an acceptable level? No: go to Q3 Yes: CCP	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels(s) No: not a CCP Yes: go to Q4	Q4 Will a subsequent step eliminate identified hazard(s) or reduce the likely occurrence to an acceptable level? No: CCP Yes: not a CCP	CCP number

22. Move to chiller	None	Yes	No	Yes	Yes	
23. Chill	BIOLOGICAL Growth of bacteria due to incorrect storage temperature and/or inadequate spacing of packages in the chilled store	Yes	Yes			2
24. Load out	BIOLOGICAL Growth of bacteria due to temperature abuse of product	Yes	No	Yes	No	3
25. Transport	BIOLOGICAL Growth of bacteria due to temperature abuse of product	Yes	No	Yes	No	4

HACCP audit table for the production of ostrich carcasses

STEP	HAZARD	CONTROL MEASURES	CCP	CRITICAL LIMIT	MONITORING	CORRECTIVE ACTION	RECORDS	VERIFICATION
1. Receive bird	Chemical-none		No					
	Physical-none							
	Biological-none							
2. Ante Mortem inspection	Chemical-none		No					
	Physical-none							
	Biological-diseased birds	Trained and qualified inspector employed and approved by regulatory authority						
3. Restrain	Chemical-none		No					
	Physical-none							
	Biological-none							

4. Stun bird	Chemical-none		No					
	Physical-none							
	Biological-none							
5. Cut throat, heart stick	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from feathers/skin to carcass	Correct procedure for incision by trained operator Cleaning and sanitation procedures for equipment						
6. Break neck	Chemical-none		No					
	Physical-none							
	Biological-none							

7. Remove head	Chemical-none		No					
	Physical-none							
	Biological-none							
8. Pluck feathers	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from feathers/skin to carcass	Correct plucking procedure including removal of feathers from carcass processing area Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures						

9. Remove legs	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from operators hands	Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures						

10. Skin	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from feathers/skin to carcass	Correct skinning procedure including removal of skin from carcass processing area Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures						

11. De-fat carcass	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from operators hands	Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures in place						
12. Eviscerate	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from ruptured intestinal contents	Feed withdrawn from animals prior to slaughter Correct evisceration procedures to minimise spillage						

13. Post mortem inspection	Chemical-none		No					
	Physical-none							
	Biological-diseased birds	Trained and qualified inspector employed and approved by regulatory authority						
14. Remove neck	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contaminatio n from operators hands	Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures in place						

15. Remove ribcage	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from operators hands	Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures in place						
16. Inspect and trim carcass	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from operators hands	Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures in place						

17. Split carcass	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from operators hands	Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures in place						
18. Move to chiller	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from operators hands	Personal hygiene procedures in place						

19. Chill	Chemical-none		Yes					
	Physical-none		1					
	Biological-excessive growth of contaminating bacteria	Reduction of carcass temperature (surface and internal) in a reasonable amount of time to minimise increase in numbers of enteric pathogens		Deep muscle temperature of carcasses down to 7°C within 24 hours of stunning Ensure carcasses are spaced so as not touching	Monitor chillier continuously with disk recording thermometer Or Monitor surface and internal temperature of 5 randomly selected carcasses per day per chiller with hand held thermometer Or Check temperature of carcasses and room regularly Monitor carcass spacing at time of chiller loading	Retain product, evaluate significance of deviation, determine product disposition Notify appropriate officer(s) Identify cause and prevent recurrence Notify maintenance to adjust refrigeration if necessary Adjust carcass spacing and retrain employees if necessary	Temperature monitoring records for both product and chiller Corrective action records Calibration and maintenance records for temperature monitoring equipment	HACCP coordinator or trained employee must review HACCP records daily prior to load out Regular calibration of thermometers Daily carcass temperature checks to verify that 7°C surface temperature is achieved Regular microbiological testing of carcasses for *E. coli* and *Salmonella*

20. Trim/bone carcass	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from operators hands	Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures in place						
21. Pack	Chemical-none		Yes					
	Physical-presence of microchips	Detection system in place for microchips and subsequent removal if present	2	Detection system sensitivity adequate to detect microchips	Designated officer to check detection system every 30 minutes	Stop packaging. Identify last 30 minutes production and retest. Identify cause and prevent recurrence	Records of each 30 minute check of microchip detection system	HACCP coordinator or trained employee must review HACCP records daily prior to load out
	Biological-bacterial cross contamination from operators hands	Personal hygiene procedures in place						

22. Move to chiller	Chemical-none		No					
	Physical-none							
	Biological-none							

23. Chill	Chemical-none		Yes					
	Physical-none		3					
	Biological excessive growth of contaminating bacteria	Reduction of product temperature (surface and internal) in a reasonable amount of time to minimise increase in numbers of enteric pathogens		Internal temperature of ostrich meat portions at or below 5°C before transportation	Monitor chillier continuously with disk recording thermometer Or Monitor internal temperature of packed product from each chiller each day with hand held thermometer Or Check temperature of product and room regularly Monitor stacking/spacing of product at time of chiller loading	Retain product, evaluate significance of deviation, determine product disposition Notify appropriate officer(s) Identify cause and prevent recurrence Notify maintenance to adjust refrigeration if necessary Adjust product stacking/spacing and retrain employees if necessary	Temperature monitoring records for both product and chiller Corrective action records Calibration and maintenance records for temperature monitoring equipment	HACCP coordinator or trained employee must review HACCP records daily prior to load out Regular calibration of thermometers Daily product temperature checks to verify that 5°C internal temperature is achieved

24. Load out	Chemical- none		Yes					
	Physical- none		4					
	Biological excessive growth of contaminating bacteria	Ensure product temperature (surface and internal) is maintained such as to minimise increase in numbers of enteric pathogens		Ensure temperature of fresh product maintained at or below 5°C	Monitor chillier and meat transport vehicle temperature continuously with disk recording thermometer Or Monitor internal temperature of packed product from each chiller each day at time of load out with hand held thermometer Or Check temperature of product, meat transport vehicle and room regularly	Retain product, evaluate significance of deviation, determine product disposition Notify appropriate officer(s) Identify cause and prevent recurrence Notify maintenance to adjust refrigeration if necessary	Temperature monitoring records for product, meat transport vehicle and chiller Corrective action records Calibration and maintenance records for temperature monitoring equipment	HACCP coordinator or trained employee must review HACCP records daily Regular calibration of thermometers Daily product temperature checks to verify that 5°C internal temperature is achieved

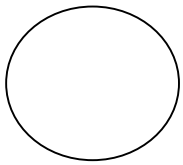
25. Transport	Chemical- none		Yes					
	Physical- none							
	Biological excessive growth of contaminating bacteria	Ensure product temperature (surface and internal) is maintained such as to minimise increase in numbers of enteric pathogens		Ensure internal temperature of fresh product maintained at or below 5°C	Monitor meat transport vehicle temperature continuously Or Monitor product with time/temperature data loggers	Retain product, evaluate significance of deviation, determine product disposition Notify appropriate officer(s) Identify cause and prevent recurrence Notify maintenance to adjust refrigeration if necessary	Temperature monitoring records for product and meat transport vehicle Corrective action records Calibration and maintenance records for temperature monitoring equipment	HACCP coordinator or trained employee must review HACCP records daily Regular calibration of thermometers Daily meat transport vehicle and/or product temperature checks

Appendix 4:
Generic HACCP plan for rabbit carcasses

PRODUCT DESCRIPTION	Rabbit meat
INTENDED END USE	Domestic wholesale market as fresh, aerobically stored and frozen product
PRESERVATION METHOD	Chilling, freezing
PACKAGING	New plastic bags in new cardboard cartons
IDENTIFICATION AND LABELLING	Full trade description
CONTROLS DURING STORAGE	Time/temperature to limit microbial growth during chilling process
CONTROLS DURING DISTRIBUTION	Time/temperature to limit microbial growth
SENSITIVE CONSUMER?	No - intended for general consumption
FINAL CUSTOMER PREPARATION	Intended to be cooked

Index of Symbols

Process



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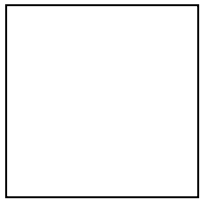

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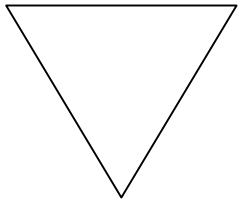

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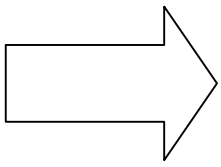
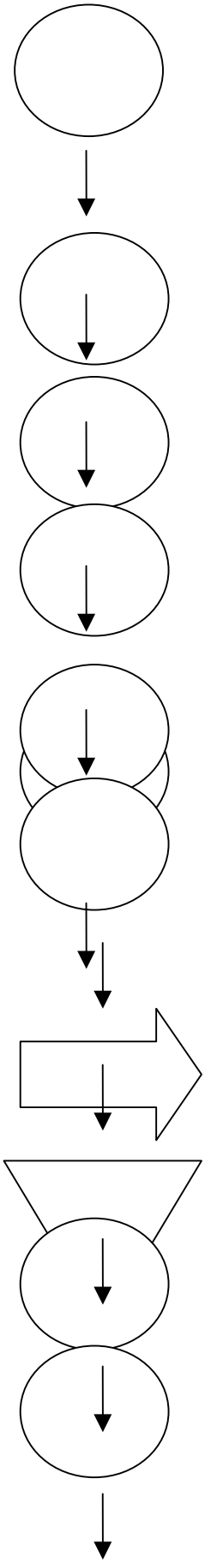


Rabbit Process Flow Chart

26. Receive rabbits
27. Stun rabbit
28. Decapitate
29. Hang
30. Skin
31. Eviscerate
32. Clean/wash carcass
33. Move to chiller
34. Chill
35. Bone carcass
36. Pack



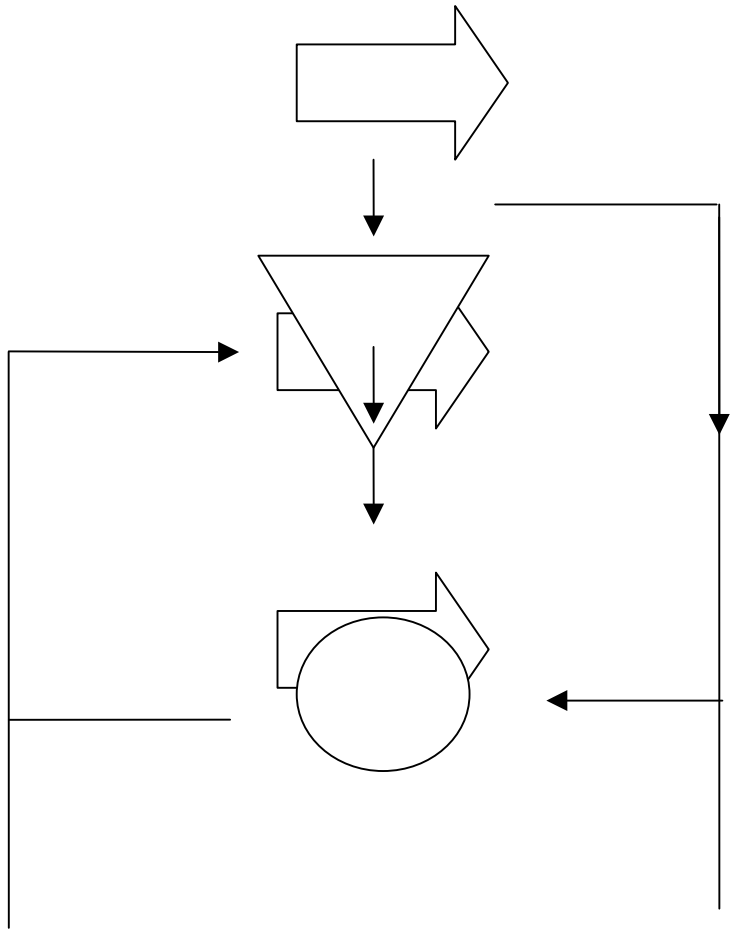
37. Move to chiller

38. Chill

39. Load out

40. Transport

Freeze



Critical Control Point Determination: Rabbit Processing

Process step/ incoming material	Identify hazard (physical, chemical, biological) Does hazard occur at this step / in this incoming material? No: go to next hazard Yes: go to Q1	Q1 Do preventive measures exist for the identified hazard? No: not a CCP Yes: go to Q2	Q2 Does this step eliminate or reduce the likely occurrence of a hazard to an acceptable level? No: go to Q3 Yes: CCP	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels(s) No: not a CCP Yes: go to Q4	Q4 Will a subsequent step eliminate identified hazard(s) or reduce the likely occurrence to an acceptable level? No: CCP Yes: not a CCP	CCP number
1. Receive animal*	BIOLOGICAL Diseased or contaminated rabbits Stressed animals	Yes	No	Yes	No	1
2. Stun	None					
3. Decapitate	None					
4. Hang	None					
5. Skin*	BIOLOGICAL Transfer of bacteria from the pelt to the carcass and from operator to carcass	Yes	No	Yes	No	2

6. Eviscerate*	BIOLOGICAL Transfer of bacteria from the viscera to the carcass	Yes	No	Yes	No	3
7. Clean/wash carcass	None					
8. Move to chiller	BIOLOGICAL Transfer of bacteria from operators hands to carcass	Yes	No	Yes	Yes	
Process step/ incoming material	Identify hazard (physical, chemical, biological) Does hazard occur at this step / in this incoming material? No: go to next hazard Yes: go to Q1	Q1 Do preventive measures exist for the identified hazard? No: not a CCP Yes: go to Q2	Q2 Does this step eliminate or reduce the likely occurrence of a hazard to an acceptable level? No: go to Q3 Yes: CCP	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels(s) No: not a CCP Yes: go to Q4	Q4 Will a subsequent step eliminate identified hazard(s) or reduce the likely occurrence to an acceptable level? No: CCP Yes: not a CCP	CCP number
9. Chill*	BIOLOGICAL Growth of bacteria due to incorrect storage temperature and/or inadequate spacing of carcasses in the chiller	Yes	Yes			4
10. Bone carcass	BIOLOGICAL Transfer of bacteria from operators hands and contact	Yes	No	Yes	Yes	

	surfaces to meat					
11. Pack	BIOLOGICAL Transfer of bacteria from operators hands to meat	Yes	No	Yes	Yes	
12. Move to chiller	BIOLOGICAL Transfer of bacteria from operators hands to carcass	Yes	No	Yes	Yes	
Process step/ incoming material	Identify hazard (physical, chemical, biological) Does hazard occur at this step / in this incoming material? No: go to next hazard Yes: go to Q1	Q1 Do preventive measures exist for the identified hazard? No: not a CCP Yes: go to Q2	Q2 Does this step eliminate or reduce the likely occurrence of a hazard to an acceptable level? No: go to Q3 Yes: CCP	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels(s) No: not a CCP Yes: go to Q4	Q4 Will a subsequent step eliminate identified hazard(s) or reduce the likely occurrence to an acceptable level? No: CCP Yes: not a CCP	CCP number
13. Chill*	BIOLOGICAL Growth of bacteria due to incorrect storage temperature and/or inadequate spacing of packages in the chiller	Yes	Yes			5
14. Load out	BIOLOGICAL	Yes	No	Yes	No	6

	Growth of bacteria due to temperature abuse of product					
15. Transport	BIOLOGICAL Growth of bacteria due to temperature abuse of product	Yes	No	Yes	No	7
16. Freeze	BIOLOGICAL Growth of bacteria due to incorrect storage temperature and/or inadequate spacing of packages in the chiller	Yes	Yes			8

*Critical control points designated by the current Australian Standard (AS 4466:1997 Hygienic production of rabbit meat for human consumption SCARM Report No 59)

HACCP audit table for the production of rabbit carcasses

STEP	HAZARD	CONTROL MEASURES	CCP	CRITICAL LIMIT	MONITORING	CORRECTIVE ACTION	RECORDS	VERIFICATION
1. Receive animal*	Chemical-contaminated rabbits	Control medication and observe with-holding periods	Yes	No animals accepted for slaughter that do not conform to with holding periods for organic or inorganic medication	Trained and qualified inspector employed and approved by regulatory authority inspects animals on receipt	Contaminated animals are removed and not slaughtered	Vendor declarations	
	Physical-none							
	Biological-diseased/stressed animals	Trained and qualified inspector employed and approved by regulatory authority		Lairage is covered for darkness and has adequate ventilation with water available No animals accepted for slaughter that are diseased	Trained and qualified inspector employed and approved by regulatory authority inspects animals on receipt	Contaminated animals are removed and not slaughtered	Ante-mortem inspection report	
2. Stun	Chemical-none		No					
	Physical-none							
	Biological-none							
3.	Chemical-		No					

Decapitate	none							
	Physical-none							
	Biological-none							
4. Hang	Chemical-none		No					
	Physical-none							
	Biological-none							
5. Skin*	Chemical-none		Yes					
	Physical-none							
	Biological-bacterial cross contamination from fur/skin to carcass	Correct skinning procedure including removal of skin from carcass processing area Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures		No visible faecal or fur contamination of the carcass	Designated employee to check for visible faecal and fur contamination of the carcasses every 2 hours	Trim affected carcasses. Identify cause and prevent recurrence Retrain staff if necessary.	Acceptable quality limits inspection report for carcasses	

6. Eviscerate*	Chemical-none		Yes					
	Physical-none							
	Biological-bacterial cross contamination from ruptured intestinal contents	Feed withdrawn from animals prior to slaughter Correct evisceration procedures to minimise spillage		No spillage of stomach/intestines	Designated employee to inspect the evisceration process every 2 hours for correct technique	Trim/rework affected carcasses. Identify cause and prevent recurrence Retrain staff if necessary.	Acceptable quality limits inspection report for carcasses	
7. Clean/wash carcass	Chemical-none		No					
	Physical-none							
	Biological-none							
8. Move to chiller	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from operators hands	Personal hygiene procedures in place						

9. Chill	Chemical- none		Yes					
	Physical- none							
	Biological- excessive growth of contaminating bacteria	Reduction of carcass temperature (surface and internal) in a reasonable amount of time to minimise increase in numbers of enteric pathogens		Deep muscle temperature of carcasses down to 5°C within 2 hours of daily slaughter operation	Monitor chillier continuously with disk recording thermometer Or Monitor surface and internal temperature of 5 randomly selected carcasses per day per chiller with hand held thermometer Or Check temperature of carcasses and room regularly Monitor carcass spacing at time of chiller loading Record temperature of carcasses 2 hours after daily slaughter operation	Retain product, evaluate significance of deviation, determine product disposition Notify appropriate officer(s) Identify cause and prevent recurrence Notify maintenance to adjust refrigeration if necessary Adjust carcass spacing and retrain employees if necessary	Temperature monitoring records for both product and chiller Corrective action records Calibration and maintenance records for temperature monitoring equipment	HACCP coordinator or trained employee must review HACCP records daily prior to load out Regular calibration of thermometers Daily carcass temperature checks to verify that 5°C surface temperature is achieved Regular microbiological testing of carcasses for *E. coli* and *Salmonella*

10. Bone carcass	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from feathers/skin to carcass	Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures in place						
11. Pack	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from operators hands	Cleaning and sanitation procedures for meat contact surfaces and personal equipment Personal hygiene procedures in place						

12. Move to chiller	Chemical-none		No					
	Physical-none							
	Biological-bacterial cross contamination from ruptured intestinal contents	Personal hygiene procedures in place						

13. Chill	Chemical- none		Yes					
	Physical- none							
	Biological- excessive growth of contaminating bacteria	Reduction of carcass temperature (surface and internal) in a reasonable amount of time to minimise increase in numbers of enteric pathogens		Deep muscle temperature of carcasses down to 5°	Monitor chillier continuously with disk recording thermometer Or Monitor internal temperature product each day per chiller with hand held thermometer Or Check temperature of product and room regularly Monitor product stacking/spacing at time of chiller loading	Retain product, evaluate significance of deviation, determine product disposition Notify appropriate officer(s) Identify cause and prevent recurrence Notify maintenance to adjust refrigeration if necessary Adjust product stacking/spacing and retrain employees if necessary	Temperature monitoring records for both product and chiller Corrective action records Calibration and maintenance records for temperature monitoring equipment	HACCP coordinator or trained employee must review HACCP records daily prior to load out Regular calibration of thermometers Daily product temperature checks to verify that 5°C internal temperature is achieved

14. Load out	Chemical- none		Yes					
	Physical- none							
	Biological excessive growth of contaminating bacteria	Reduction of carcass temperature (surface and internal) in a reasonable amount of time to minimise increase in numbers of enteric pathogens		Ensure temperature of fresh product maintained at or below 5°C	Monitor chillier and meat transport vehicle temperature continuously with disk recording thermometer Or Monitor internal temperature of packed product from each chiller each day at time of load out with hand held thermometer Or Check temperature of product, meat transport vehicle and room regularly	Retain product, evaluate significance of deviation, determine product disposition Notify appropriate officer(s) Identify cause and prevent recurrence Notify maintenance to adjust refrigeration if necessary	Temperature monitoring records for product, meat transport vehicle and chiller Corrective action records Calibration and maintenance records for temperature monitoring equipment	HACCP coordinator or trained employee must review HACCP records daily Regular calibration of thermometers Daily product temperature checks to verify that 5°C internal temperature is achieved

15. Transport	Chemical-none		Yes					
	Physical-none							
	Biological excessive growth of contaminating bacteria	Reduction of carcass temperature (surface and internal) in a reasonable amount of time to minimise increase in numbers of enteric pathogens		Ensure internal temperature of fresh product maintained at or below 5°C	Monitor meat transport vehicle temperature continuously Or Monitor product with time/temperature data loggers	Retain product, evaluate significance of deviation, determine product disposition Notify appropriate officer(s) Identify cause and prevent recurrence Notify maintenance to adjust refrigeration if necessary	Temperature monitoring records for product and meat transport vehicle Corrective action records Calibration and maintenance records for temperature monitoring equipment	HACCP coordinator or trained employee must review HACCP records daily Regular calibration of thermometers Daily meat transport vehicle and/or product temperature checks

16. Freeze	Chemical- none		Yes					
	Physical- none							
	Biological- Growth of bacteria due to incorrect storage temperature and/or inadequate spacing of packages in the chiller	Reduction of carcass temperature (surface and internal) in a reasonable amount of time to minimise increase in numbers of enteric pathogens		Deep muscle temperature at or below -15°C within 96 hours of stunning	Monitor freezer continuously with disk recording thermometer Or Monitor internal temperature randomly selected product each day per freezer with hand held thermometer or time/temperature datalogger Or Check temperature of product and room regularly Monitor product stacking/spacing at time of chiller loading	Retain product, evaluate significance of deviation, determine product disposition Notify appropriate officer(s) Identify cause and prevent recurrence Notify maintenance to adjust refrigeration if necessary Adjust product stacking/spacing and retrain employees if necessary	Temperature monitoring records for both product and chiller Corrective action records Calibration and maintenance records for temperature monitoring equipment	HACCP coordinator or trained employee must review HACCP records daily prior to load out Regular calibration of thermometers Daily product temperature checks to verify that -15°C internal temperature is achieved