final report

Project code: P.PSH.0679

Prepared by: Joanne Galletly – Business Innovation Manager
Top Cut Foods Pty Ltd

Date published: 14th January 2016

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Dry Aged Beef – Design and Good Manufacturing Practices Review

This is an MLA Donor Company funded project.

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

Abstract

Prior to the 1960's the traditional method for ageing beef was dry ageing. Unpackaged beef carcasses and cuts were hung or racked in chillers with controlled temperature and relative humidity conditions. Ageing in these conditions is believed to give beef a characteristic beefy, roast, buttery, nutty flavour. The processing parameters for dry ageing differ from the present day commercial ageing method known as wet ageing. The flavour imparted by the dry ageing process and the subsequent yield loss as a result of the process means dry aged beef commands a premium in the high quality restaurant and retail markets. Research has shown that the major factors influencing the sensory qualities of dry aged beef are; storage temperature, ageing time, relative humidity and air flow. Ensuring compliance with the set points within these parameters controls the growth of undesirable microorganisms. The set points also need to allow the process to be economically viable keeping yield loss to a minimum. The purpose of this project was to review and trial dry ageing protocols to develop best practice principles for dry ageing beef in Australia.

This report details key operational parameters such as storage temperature between 0.5-1.5°C, relative humidity between 75-85%, air flow 0.2-0.5m/s and the use of UV lights. Other factors to take into consideration include raw material selection, chiller set up and air flow around the primals being dry aged. A set of Good Manufacturing Practice Guidelines cover these parameters in greater detail. Trials carried out at Top Cut Foods Burleigh Heads dry ageing facilities also investigated different dry ageing treatments such as specialist packaging called Tublin and the use of salt walls. The trials confirmed the effects of the various processing parameters and treatments on yield loss and microbial loading of dry aged beef as per publications referenced in this report.

Acronyms

ANZFSC	Australia New Zealand Food Standards Code
AS4696:2007	Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption
CCP	Critical Control Point
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis Critical Control Point
MLA	Meat and Livestock Australia
NATA	National Association of Testing Authorities
RH	Relative Humidity
U.S.	United States of America
UV	Ultra Violet

Table of Contents

1 Dry Aged Beef

Ageing is common practice in the meat industry and is associated with improving a number of meat quality parameters including tenderness and flavour. The practice of holding meat over a period of time, usually longer than 14 days, in controlled chilled conditions allows for endogenous enzyme action which causes protein degradation and therefore improves meat tenderness. Prior to the 1960's meat was stored exposed to the environment in chillers that had tightly controlled temperatures, relative humidity's and air flow. When considering evaporation and trimming, this method known as dry ageing, can result in yield losses of up to 50%. Dry ageing however produces meat with a distinctive flavour profile. Ageing meat in vacuum packed bags under chilled conditions was developed in the 1960's to improve yield and is known as wet ageing. These days, consumers are most familiar with wet aged meat due to it being the most economically viable ageing method.

Evaporative loss during dry ageing is thought to cause the concentration of proteins and other compounds in muscle meat producing a roast, buttery, nutty flavour. The processing parameters used to develop these dry aged flavours are explained in section 1.2. In a study looking at the palatability of dry-aged and wet-aged beef rib-eye, X Li et al., (2014) suggest that the oxidation of lipids and the formation of volatile compounds may be of importance to some sensory aspects of dry aged beef.

Dry aged meat has increased in popularity in the high quality restaurant and retail markets. Due to the yield losses and the claimed quality improvements, dry aged meat is marketed as a niche product and consumers can expect to pay a premium for it. For this reason processors tend to select higher grade Angus and Wagyu, striploin or ribeye steak cuts.

Figure 1: Dry aged bone in striploin produced at Top Cut Foods

2 Operational Parameters

2.1 Research Review

Of the limited international research carried out on dry aged beef, most has been completed in the United States. For this project nine journal articles relating to dry aged beef were reviewed. Results across these studies varied with regard to preferred meat flavours and yields. The treatments were variable and in most cases there were limited comparisons made between the sensory traits of the final product and the chiller parameters and ageing times.

The U.S. Meat Export Federation has published on their website guidelines for U.S. dry-aged beef for the international market based on study completed by Oklahoma State University. These guidelines outline the dry ageing process and give specific information for the preparation and processing of dry aged beef. Meat and Livestock Australia (MLA) released a Technology Update on dry ageing beef in 2010. The guidelines were based on literature reviews and detailed the effects of chiller parameters on dry aged beef. Their recommended parameters are listed in Table 1 of section 3.

In 2008 the U.S. National Cattlemen's Beef Association prepared an executive summary on dry ageing beef. The review detailed the most important dry ageing parameters: 1) days of ageing, 2) storage temperature, 3) relative humidity and 4) air flow. Results from Top Cut Foods trials also suggest UV lighting is important when dry ageing beef. The listed parameters affect the yield, flavour, and shelf life of the product and therefore are of economic, quality and food safety importance.

2.1.1 Ageing Time

In the reviewed studies most loin cuts were dry aged for 21 days (range 21-35 days), post 6-11 days wet ageing. The ageing time may affect the development of dry aged flavour as well as improve tenderness. The results across the studies suggest that there is no linear relationship between organoleptic characteristics and ageing time. It is understood however that during ageing endogenous proteolytic enzymes are still active after 21 days, hence improved meat tenderness over time. It could also be assumed that evaporative loss over time will assist with flavour development due to the concentration and oxidation of flavour compounds in the meat. The suggested minimum ageing time for dry ageing to gain the characteristic flavour profile and desirable tenderness as stated by the National Cattlemen's Association guidelines and the MLA technology update is 14 days. Top Cut Foods trial results suggest longer ageing periods of up to 43 days dry ageing will improve meat flavour. Anecdotally, dry ageing for longer than 43 days was found to produce more pronounced dry aged flavours.

2.1.2 Storage temperature

Storage temperature has an effect on the activation of the endogenous enzymes responsible for tenderising meat as well as controlling the growth of microbes. The lower the temperature, the slower the enzyme action. It is however beneficial to store meat at low temperatures to control bacterial and fungal growth. Pseudomonas *spp* spoilage bacteria are psychrotrophic and can grow in temperatures as low as -6°C. Most pathogenic bacteria however need temperatures above 4°C for growth and/or production of toxins. The U.S.

National Cattlemen's Association guidelines suggest a temperature range of 0-4°C, whereas the MLA Technology Update (2010) proposes a lower temperature range of -0.5-1.5°C.

2.1.3 Relative Humidity

The relative humidity (RH) of a dry aged chiller can affect microbial growth and yield loss. If the RH is too high the water activity (a_w) of the exterior surface of the meat will be high allowing the growth of bacteria and fungi. If the RH is too low there will be excessive evaporative loss which is of economic concern. Not all of the studies reviewed considered the effects of RH on yield loss and the microbial growth of dry aged beef. The MLA Technology update suggests an RH range of 75-85%.

2.1.4 Air Flow

There is little research completed on the effect of air flow on dry aged beef processing however ensuring constant air flow around the entire cut being dry aged aids even drying, minimising spoilage and therefore off-odour and off-flavour development. The U.S. export guidelines suggest an air flow between 0.5m/s and 2.0m/s. The MLA Technology update suggests a lower air velocity of 0.2m/s to 0.5m/s. There have been no reported relationships between air velocity and yield loss due to evaporative shrinkage and only a couple of the reviewed studies measured or reported air velocity. It can be expected however that yield loss due to evaporation will increase with higher air velocity and lower relative humidity.

2.1.5 UV Radiation

Ultra violet (UV) radiation can be used in chillers to improve the shelf life of meat. UV radiation at wavelengths between 200-300nm has been shown to be effective at killing or damaging microorganisms. The closer the UV radiation is to a meat surface the more the bactericidal effect it can have. Microorganisms however can grow in the areas on the surface of the meat where the UV radiation casts shadows i.e. rough surfaces. UV radiation can also be used to disinfect the air in a chiller by circulating air through UV units. An alternative air cleansing technology called BAXX uses cold plasma to kill airborne bacteria, viruses and fungal spores. Hydroxyl units created by the interaction of the moisture in the air and cold plasma bind to the cell walls of microorganisms disrupting their metabolism and killing them. The recommended number of UV units for a dry aged chiller (based on Australian Ultraviolet P/L model G24 IM) is one unit per $5m^2$. It is necessary to change the unit UV bulbs every six months to maintain the effectiveness of the UV radiation.

2.2 Alternative Treatments

Today's dry ageing practices are based on traditional dry ageing techniques and apart from improvement in existing technologies, the process is relatively unchanged. There are however alternative treatments such as salt walls, Tublin and batch chilling that may improve the yield and quality of dry aged meat. These are discussed below.

2.2.1 Salt Wall

Salt is hygroscopic and therefore can remove moisture from the air. Despite the common use of salt walls which create a theatrical effect, there was no research found on the use of salt walls in dry aged chillers. During the Top Cut Foods trials it was determined that if a chiller had an effective refrigeration unit capable of reducing the relative humidity of the air then salt blocks were not necessary. In artisan style butcheries with small display chiller

units, salt blocks may be of benefit to reduce relative humidity and also add to the 'theatre' of the process. The possible effects of salt walls on meat flavour have yet to be elucidated.

Image 1: Example of a Himalayan Salt Wall Unit

2.2.2 Tublin

There are dry ageing bags available that are highly permeable to water vapour. Danish firm, Tub-Ex ApS, produces a bag with a water vapour transmission rate of 5000g/50µ/m^2/24h @ 38°C and 50% RH, called Tublin 10. Tub-Ex ApS claims the bag allows moisture to permeate out and at the same time block oxygen from entering the bag therefore drying the meat but avoiding dry crust and contamination. Many studies have assessed the effectiveness of the bag. In studies by Ahnstrom et al., (2006) and X Li et al., (2014) consumers found the taste attributes of beef dry aged in Tublin were equivalent to traditional dry aged beef. X Li et al., (2014) also found lower total plate counts, enterobacteriaceae and yeast counts on the surface of meat aged in Tublin bags compared to traditional dry ageing.

In the Top Cut Foods trials the Tublin bag samples had the lowest evaporative yield loss of 12%. The bulk packed grain fed shell loin samples lost an average of 14.2% compared to the vacuum packed shell loin average of 16.5%. Studies that looked at dry aged beef vacuum packed using Tublin have shown evaporative losses of 8.8%, 13.48% and 15.3% (Ahnstrom et al. 2006; Dikeman et al. 2013; Xin Li et al. 2013). These results were obtained from striploins (first two studies) and rump respectively and all samples were aged for 21 days. The results from these studies were similar to the evaporative losses of the Tublin packed beef shell loins found in the Top Cut Foods trials.

The Tublin bags had some processing inconsistencies. Many bags failed to seal and had to be re-packed. Three of the six samples also lost some vacuum during the storage period resulting up to 3% higher evaporative yield loss compared to the packs that maintained their vacuum. The bags purchased for this trial were $4 each, however it would expected that the price would be less if bought in significant quantities. It was calculated that the bag at $4ea would add a ~$1.50/kg cost after accounting for the improvement in yield loss.

2.2.3 Batch Chillers

Ideally a dry crust is formed quickly on the exterior of raw meat in the initial stages of the dry ageing process. To create this crust there needs to be sufficient air flow and a suitable relative humidity in the chiller used. A step by step process of initial crust formation, drying and then holding would be ideal for ensuring the best quality and yield results for dry aged beef. To achieve this it would be desirable to have a series of chillers whereby batches are subjected to a cycle or where batches are moved to chillers based on their step within the cycle.

The ability to control the drying and therefore quality and yield loss could assist with increasing the premium price point however a cost benefit analysis would need to be performed assessing the capital expenditure required to set up the process compared expected yield and quality improvement and therefore finished product price.

3 Good Manufacturing Practice Guidelines (Including HACCP)

3.1 Food Safety and HACCP

A set of good manufacturing practice (GMP) guidelines for the production of dry aged red meat were developed in conjunction with consultant Steve Bonney of Norlane Trading and are located in appendix. The guidelines included a generic process flow, HACCP plan and finished product specification. The list below gives a brief description of what was included in the guidelines.

3.1.1 Process Flow

A generic process flow was presented in the guidelines and includes average expected yield losses during the dry age process. The process flow also states some key processing conditions which are further detailed in the GMP section.

3.1.2 HACCP Plan

A generic HACCP plan was written for the dry ageing process. The HACCP plan covered raw material recieval through to storage of finished product. A HACCP audit table was also presented. The generic HACCP plan suggested a storage temperature critical control point however processors must determine the risks associated with their own process and facilities.

3.2 Good Manufacturing Practice

Good manufacturing practice guidelines were detailed in the paper and were separated into key process steps as per the below list. Key processing parameters and notes are listed.

a) Procurement of Raw Material

- Procure quality and wholesome raw material from approved suppliers

b) Acceptance of Raw Material

- Receive raw material at a temperature of <5°C
- Assess wholesomeness of raw material upon recieval

c) Initial (Pre-Dry Age) Storage

- Store raw material at <5°C for a maximum of 48 hours

d) Un-pack, Identify and Transfer Product to Dry Age Chiller

- Raw material is to be labelled. Labels must not cause contamination
- Pack raw material on to trolleys/shelves allowing adequate air flow between each cut
- No piercing, needling or mechanical tenderisation of raw material should be permitted
- Raw material must be inspected for contamination prior to loading into dry aged chiller

e) Dry Ageing

- UV Lighting – 1 unit per $5m^2$. Change bulbs on a six monthly basis
- Air Flow and Relative Humidity – 0.2-0.5m/s and 75-85% respectively

- Chiller and Product Temperature – 0.5°C
- Ageing Time – Minimum 14 days

f) Finished Dry Age Product Trimming and Packing

- Finished product and packing to be carried out in separate, clean area
- Face cuts can be removed. Trimmings are to be placed in bins marked inedible and discarded as waste
- Products to be packed immediately and labelled appropriately
- Validate shelf life – dependant on finished product packaging

g) Thermometers/Relative Humidity Probes and Dataloggers

- Ensure probes and dataloggers are scheduled for calibration

h) Chiller Cleaning

- Need beneficial bacteria and do not want excessive water in the chiller/cabinet
- Dry clean when required. Observe mould growth and assess smell on a weekly basis

i) Chiller Fogging

- If excessive fungal growth is observed on product or in the chiller fogging may be necessary

3.3 Finished Product Specification

A generic finished product specification was included in the guidelines. There were critical items specified to ensure the customer is adequately informed of the food safety controls pertaining to dry aged product. The specification details customer preparation requirements in store.

4 Key Messages

The key messages taken from this project including trial results and research reviews are listed below:

- Ideal processing parameters to produce wholesome and quality dry aged beef are listed below. These can be implemented in hurdle effect:
  - Temperature 0.5-1.5°C
  - Relative Humidity 75-85%
  - Air Speed 0.2-0.5m/s
  - Ageing period minimum 14 days

  Depending on the equipment design and process set up these parameters may vary but deliver similar results. I.e. a chiller temperature of 0.5°C and the installation of UV lights may allow for an RH of 90% and an air speed of 0.2m/s.

  Other factors to take into consideration include raw material, chiller set up and air flow around the primals being dry aged.

- Meat surfaces should be dry and free from mould, yeast and spoilage bacteria. Off odours, visible mould and yeast growth and surface stickiness indicate an underperforming dry ageing chiller or cabinet and/or a recurring source of contamination i.e. mould in refrigeration fan units.

- Relative humidity parameters can be achieved by equipment design and/or installation of salt walls depending on the size of the chiller.

- Working UV lights assist with the control of microbes.

- Evaporative yield losses depend on the dry ageing process and ageing period. Expect evaporative losses of approximately 15% after 6 weeks ageing. Further losses of 15-30% will occur due to trimming.

- The Tublin bags had some processing inconsistencies in terms of sealing and maintaining vacuum.

- For large scale dry ageing facilities a refrigeration unit capable of controlling relative humidity is more effective than using salt blocks. Salt walls however create a theatrical effect and may have some moisture removing abilities in a smaller display type set up.

- Legislation should allow processors to show control of the process rather than dictate expensive microbial testing programmes for a product that has similar consumer outcomes to wet aged meat.

- Post ageing preparation of finished product needs to be tightly controlled to inhibit cross contamination and therefore improve the shelf life of the finished product. All trimmings must be disposed of.

5 Bibliography

Adhikari, K., Chambers IV, E., Miller, R., Vazquez-Araujo, L., Bhumiratana, N., Philip, C., (2011) Development of a Lexicon for Beef Flavour in Intact Muscle. *Journal of Sensory Studies 26; 413-420*

Ahnstrom, M.L., Seyfert, M., Hunt, M.C., Johnson, D.E., (2006) Dry aging of beef in a bag highly permeable to water vapour. *Meat Science 73; 674-679*

Deak, T. and Beuchat, L.R., (1996) Handbook of Spoilage Yeasts. CRC Press p93

Dikeman, M.E., Obuz, E., Gok, V., Akkaya, L., Stroda, S., (2013) Effects of dry, and special bag aging; USDA quality grade; and end point temperature on yields and eating quality of beef *Longissimus lumborum* steaks. *Meat Science 94; 228-233*

Levenson, D., Pfaller, M.A., Smith, M.A., Hollis, R., Gerarden, T., Tucci, C.B., Isenberg, H.D., (1991) Candida zeylanoides: Another Opportunistic Yeast. Journal of Clinical Microbiology 8; 1689-1692

Li, X., Babol, J., Bredie, W.L.P., Nielson, B., Tomankova, J., Lundstrom, K., (2014) a comparative study of beef quality after ageing *longissimus* muscle using a dry ageing bad, traditional dry ageing or vacuum package ageing. *Meat Science 97; 433-442*

Li, X., Babol, J., Wallby, A., Lundstrom, K., (2013) Meat quality, microbiological status and consumer preference of beef *gluteus medius* aged in a dry ageing bag or vacuum. *Meat Science 95; 229-234*

Savell, J.W. (2008) Dry-aging of beef, executive summary. U.S. National Cattlemen's Beef Association.
http://beefresearch.org/CMDocs/BeefResearch/Dry%20Aging%20of%20Beef.pdf

Meat and Livestock Australia - Meat Technology Update 2/10 (2010) Dry ageing beef.
http://www.meatupdate.csiro.au/data/MEAT_TECHNOLOGY_UPDATE_10-2.pdf

U.S. Meat Export Federation – Guidelines for U.S. Dry-Aged Beef for International Markets
http://www.usmef.org/guidelines-for-u-s-dry-aged-beef-for-international-markets/

6 Appendix

Dry Ageing Guidelines

July 2015

Guidelines Compiled By:

Joanne Galletly (Business Innovation Manager – Top Cut Foods Pty Ltd.)

Steve Bonney (Smallgoods Consultant – Norlane Trading Ltd.)

Background

Prior to the 1960's the traditional method for improving beef tenderness and flavour was dry ageing. Unpackaged beef carcasses and cuts were hung or racked in chillers with controlled temperature and relative humidity. Ageing in these conditions is considered to impart characteristic beefy, roast, buttery flavours due to the concentration of flavour compounds. The processing parameters for dry ageing differ from the present day commercial ageing method known as wet ageing. Wet ageing involves storing meat cuts in vacuum packed bags under chilled conditions. The flavour imparted by the dry ageing process and the subsequent yield loss as a result of the process means dry aged beef commands a premium in the high quality restaurant and retail markets. Research has shown that the major factors influencing the sensory qualities of dry aged beef are; storage temperature, ageing time, relative humidity and air flow. It is desirable to install purpose built dry ageing facilities to ensure tight control of the above parameters. Some Australian processors have invested in such facilities on both small and large scales. Ensuring compliance with the set points within these parameters should control the growth of undesirable microorganisms. The parameters also need to be set so that the process is economically viable keeping yield loss to a minimum.

These guidelines outline a generic HACCP plan and recommend Good Manufacturing Practices to ensure dry aged beef is produced a wholesome, quality product. A generic finished product specification detailing information specific to customer preparation is also included.

Acronyms and Glossary

CCP	Critical Control Point
CP	Control Point
DFD	Dark Firm Dry
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis Critical Control Point
PPE	Personal Protective Equipment
SP	Supporting Programme
UV	Ultra Violet

Dry Aged Chiller: Refrigerated room, chamber or cabinet designed for the dry ageing of Beef

Contents

1. Process Flow

Figure 1 presents a generic process flow for the production of dry aged beef. The left column outlines key processing conditions and the right column indicates expected yield losses encountered during the dry ageing process. The Good Manufacturing Practices (GMP's) in section 3 further detail the process steps. The GMP's provide information regarding food safety as well as ideal processing parameters as identified during trials and reviews of international research articles.

1.1 Yield

Moisture loss during dry ageing is crucial for the concentration of flavour compounds. This however has a negative effect on yield and the economic viability of the process. Yield loss occurs during various steps in the dry age process. The first occurrence will be either at the point of raw material receival for bulk packed cuts or upon opening of packaging for vacuum packed cuts. Bulk packed product will lose 1-3% yield due to evaporation during the transport process. The evaporative loss will be determined by the length of time in transit and transit temperature. For vacuum packed product the average yield loss due to purge is 2-4%.

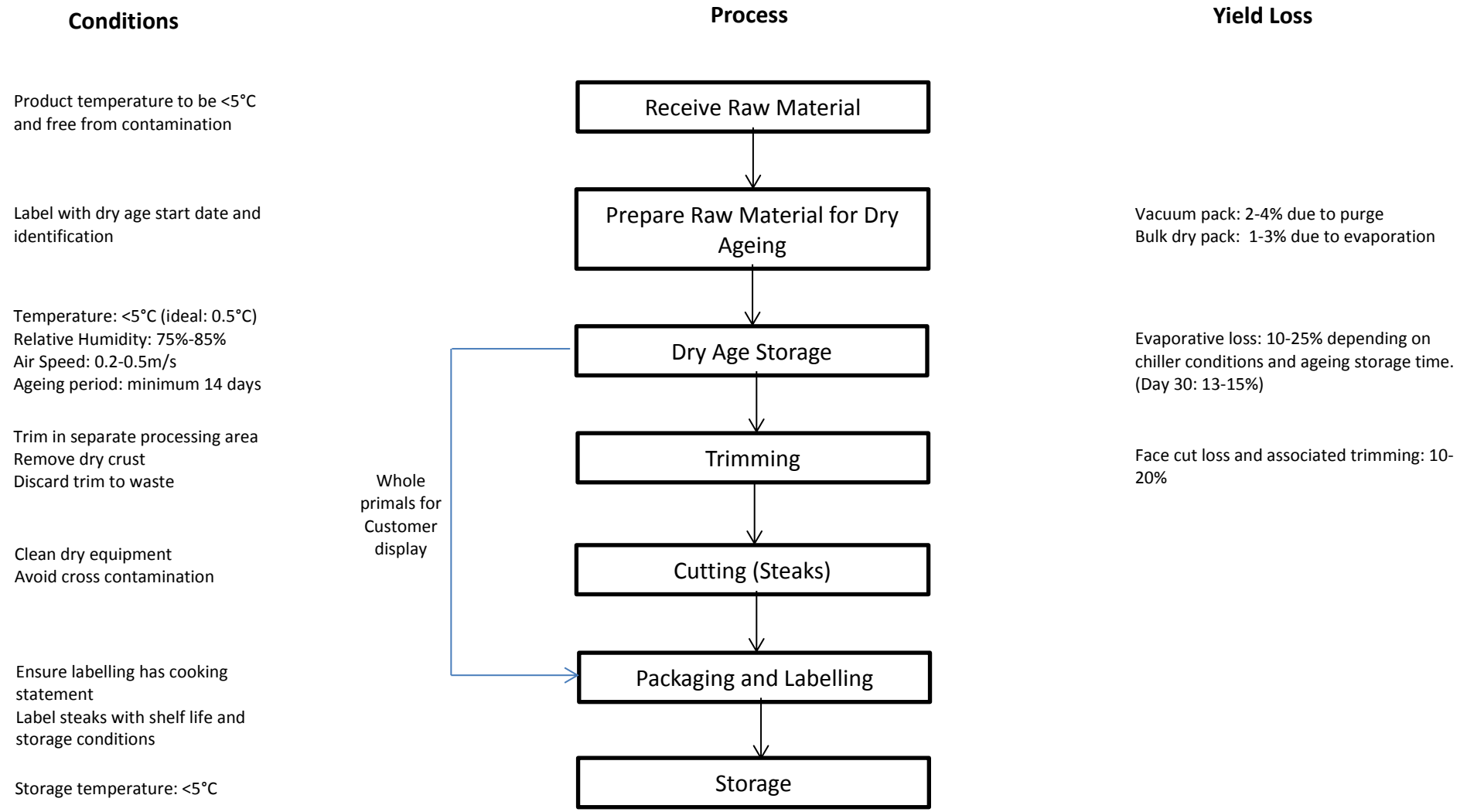
The second yield loss phase occurs during dry age storage. The yield loss percentage is relative to the chiller conditions. Low relative humidity and high air flow will cause higher yield loss due to evaporation. Length of storage time will also affect evaporative yield loss. The longer a cut is exposed to dry age chiller conditions the more evaporative loss that will occur. Yield losses during this phase can be up to 25% however the average expected loss is 13-15%.

To ensure a wholesome product is presented to the customer the dry crust from the exterior of a dry aged cut needs to be trimmed and discarded as waste. The trimming loss associated with removing the face of each end of a whole primal will be dependent on the primal type, grade, size and ageing time. The loss due to removing face cuts ranges between 10% and 20%. Further trimming required due to customer specifications i.e. less fat or bone removal, will increase trimming losses.

1.2 Conditions

There are various conditions vital to the dry ageing process that ensures production of safe and quality dry aged products. The parameters related to these conditions are detailed in section 3.

Figure 1. Generic process flow for dry aged beef



2. HACCP

There are many factors that affect the growth of microorganisms on raw meat. Extrinsic factors such as relative humidity, storage temperature and ageing time all can affect the growth rate of bacteria and fungi. Intrinsic factors such as initial bacterial loading and water activity (aw) can be controlled during the dry ageing process to reduce the risk of microbial growth. Incorrect processing parameters such as high storage temperatures risk the growth of pathogenic bacteria.

As per traditional meat processing it is beneficial to control the chiller parameters as well as the other extrinsic and intrinsic factors using the hurdle approach. Setting the correct chiller parameters and achieving the water activity on the outside crust of the meat to reduce microbial growth can be assisted by also ensuring the raw material has minimal microbial contamination at the start of ageing. When developing a HACCP plan and Food Safety Programme all of these factors need to be considered.

A generic HACCP plan for the dry ageing process is presented below. It covers raw material receival through to storage of finished product. A HACCP audit table is also present. It is advisable for producers of dry aged meat to identify the hazards in their process and manage them appropriately. Critical limits and variations to the process will require validation and HACCP activities must be carried out by an appropriately trained HACCP Co-ordinator.

2.1 Risk Assessment Matrix (Weighted Risk Assessment Criteria – WRAC)

There are various matrices that can be used to assess the significance of food safety hazards. The following matrix has been used for this HACCP assessment.

The matrix outlines measures of severity (consequences) and the likelihood (frequency) of a hazard. A value of 1-10 indicates a significant food safety or quality Issue (i.e. above the line). A value under 10 indicates control measures must be put in place with appropriate monitoring and records kept. Food safety issues that are not as significant will have values of 11 – 25.

It is the responsibility of the HACCP team member and the HACCP Co-ordinator to determine whether a step is a critical control point (CCP) or a control point (CP). A HACCP decision making tree (not included here) will assist with the decision making process.

HAZARD SEVERITY

1. Fatality occurrence
2. Serious Illness
3. Product Recall
4. Customer Complaint
5. Not significant

HAZARD LIKELIHOOD

A. Common repeating
B. Known to occur or 'it has happened'
C. Could occur or 'I've heard of it happening'
D. Not expected to occur
E. Practically impossible

	LIKELIHOOD				
SEVERITY	**A**	**B**	**C**	**D**	**E**
1	1	2	4	7	11
2	3	5	8	12	16
3	6	9	13	17	20
4	10	14	18	21	23
5	15	19	22	24	25

The following table is an example of a product description for dry aged beef. The listed conditions may differ depending on the process.

Table 1. Product Description

Product Description	Dry Aged Beef – Primals, Portions
Composition	Beef
Method of preservation	Chilled to <5°C Frozen to -12°C or colder
Packaging	Bulk pack primals in clean cheesecloth Vacuum packed portions Layer packed portions
Storage Conditions	Chilled <5°C Frozen <-12°C
Shelf Life	Validation required
Allergen	Nil
Distribution Method	Via registered refrigerated vehicles <5°C
Final Customer Preparation	Bulk packed primals must be hygienically trimmed of dry exterior prior to consumption. Product must be cooked to a minimum external temperature of 73°C for 1 minute.

2.3 Hazards of Concern

When assessing the hazards associated with a process, the possible contaminants (biological, physical and chemical) must be identified. Table 2 lists some of the hazards associated with meat production and in particular dry aged meat. The Guidelines for Safe Retailing of Meat and Meat Products published by Meat and Livestock Australia (2012) detail the microbiological risks associated with raw meat products. This guideline is useful for understanding the pathogenic bacteria that may infect meat and therefore pose a threat to consumer food safety.

2.3.1 Moulds and Yeasts

If the dry ageing process is carried out in un-controlled conditions, product is susceptible to the growth of moulds and yeasts. Some moulds form mycotoxins that can cause illness in humans. Although it is not common for mycotoxin producing moulds to grow on dry aged meat, moulds can proliferate at low temperatures and relative humidity. As detailed in the GMP's in section 3, to inhibit the growth of undesirable microbes including moulds and yeasts, a dry aged chiller should have a relative humidity <85% and a temperature of <5°C. It is preferable to further restrict fungal growth by maintaining a temperature of 0.5°C. If dry ageing is carried out in the appropriate conditions there should be minimal evidence of mould or yeast growth.

2.3.2 Bacteria

Listeria *monocytogenes* can grow at refrigerated temperatures but is susceptible to heat and is therefore killed during the cooking process. Other microbes of concern are controlled by chiller storage temperature or by the cooking process. Cold loving spoilage bacteria such as Pseudomonas *spp* that cause off odours and slime can grow on dry aged meat if the chiller conditions are not controlled. Spoilage bacteria require more moisture than moulds and yeasts for growth. In the ideal dry age chilling conditions as detailed in the GMP's there should be no off-odours or visible signs of spoilage.

2.3.3 Trimming

During the dry ageing process a dry crust should form on the outside of the meat. This crust may have some microbiological activity and due to dryness and colour is not organoleptically acceptable. To ensure the product meets the industry standard (AS4696:2007) for a wholesome product this crust must be hygienically removed from the meat before presentation to the customer for consumption. The trimmings should also be discarded as waste and not be used in the preparation of any other food products.

Table 2. Hazards of Concern

Hazard	Basic Microbiology	Source of Contamination	Product Association	Control Measures
Biological Salmonella	Non –spore forming. Minimum growth temperature is 7°C	Intestinal tract of animals and bird faeces	All meat products	Temperature control Cook raw meat (area of concern to +65°C)
Biological Escherichia coli 0157:H7	Non-spore aerobic organism. Minimum growth temperature is 7°C. Entero-toxigenic	Intestinal tract, faecal material, poor personal hygiene from food handlers	Contamination. 0157:H7 mostly undercooked meat	Temperature control Personal Hygiene GMP Cook raw meat (area of concern to +65°C)
Biological Staphylococcus *aureus*	Facultative anaerobe - grows best in oxygen. Minimum growth temperature is 7°C.	Food handlers. Upper respiratory tract and skin.	Raw meat products	Temperature control Personal Hygiene GMP Cook raw meat
Biological Listeria *monocytogenes*	Cold loving, salt tolerant. Can grow in aerobic and anaerobic environments.	Environment, soil, dust, water, animal foods	All meat products and surfaces	Cleaning Temperature control Cook raw meat (area of concern to +73°C for 1 minute)
Biological Moulds	Can grow at lower temperatures and require less moisture than bacteria. Prefer oxygen.	Environment, meat	Meat surfaces. Can be transferred in the air. Dry-cured meats e.g. salamis	Temperature and relative humidity control Cleaning Removal by trimming of product Cook raw meat
Biological Yeasts (e.g. Candida *zeylanoides*)	Can grow at lower temperatures and require less moisture than bacteria. Prefer	Environment, meat	Meat surfaces. Dry-cured meats e.g. salamis	Temperature and relative humidity control Cleaning

	oxygen.			Removal by trimming of product Cook raw meat
Physical Machinery Moving parts Pallets Cardboard Employees	Not applicable	Machinery, personnel, receivable goods, pallets, transport vehicles, external contractors.	Loose machinery parts nuts washers, jewellery, hair, wood particles cardboard, dust.	Metal detector, Maintenance checks and employee observations.
Chemical Cleaning chemicals, pesticides, animal health from abattoir, transport.	Not applicable	Abattoir chemicals, antibiotics, maintenance chemicals on machinery, chemical residues on contact surfaces, pesticides	Raw meat surfaces in contact with dangerous chemicals when processing	Approved supplier, pre-op checks, and external pest control program. Monitoring by staff

2.4 Hazard Analysis Table

The following hazard analysis table identifies generic hazards for a dry ageing process. Processors will need to carry out a HACCP hazard analysis specific to their process. Hazard analyses need to be performed by a trained HACCP co-ordinator in conjunction with a site HACCP team.

Critical control points (CCP's) may differ for different processes. A chilled storage CCP has been identified in this analysis however some facilities deem chilled storage a control point (CP) due to different processing parameters and risk factors. Other facilities identify the need to have a product receival or metal detection CCP. Few chemical or physical hazards are listed in the table as these are mostly facility dependant.

Table 3. Hazard Analysis Table CCP= Critical Control Point, CP=Control Point, SP= Supporting Program

PROCESS STEP	HAZARD	CAUSE	CONTROL MEASURES	WRAC No. CCP / SP
1 **Raw Material Receival**	**B**iological: Excessive microbiological load/growth on incoming meat	Poor slaughter and dressing practices at abattoir	Approved supplier program	2+D=12 SP
		Product temperature >5°C	Temperature control. Maintain meat temperature <5°C	2+D=**12** **CP1 – Receival temperature**
		Time post slaughter – bulk packed	Reject bulk packed product that is not to specification.	2+D=12 SP
	Physical: Physical contamination	Packaging damaged or meat contacted unclean surface	Inspection of delivered meat by trained personnel	4+D=21 SP
	Chemical: Nil identified			
2 **Storage**	**B**iological: Growth of pathogenic micro-organisms	High storage temperature	Temperature control. Maintain meat temperature <5°C.	2+C=**8** **CCP1 – Chilled Storage**
		Contamination due to damaged packaging or storage under potential contaminants	Product adequately contained and covered and stored separately from potential contaminants	5+D=24 SP
	Physical: Nil identified			
	Chemical: Nil identified			

3 **Dry Age Preparation**	**B**iological: Cross contamination of micro-organisms	Contamination from food handlers	GMP Personal Hygiene	2+D=12 SP
		Contamination from premises or equipment	GMP Hygiene and Sanitation.	2+D=12 SP
	Biological: Growth of pathogenic micro-organisms	Product temperature increase during processing	Product to be processed in a temperature controlled environment without delay. Room temperature <10°C.	2+D=**12** **CP2 – Processing room temperature**
		Insufficient space between cuts restricting airflow	Dry ageing operational GMP	2+D=12 CP
	Chemical: Nil identified			
	Physical: Nil identified			
4 **Dry ageing**	**B**iological: Growth of pathogenic micro-organisms	Incorrect temperature control – high temperatures	Chiller temperature to remain <5°C. *Dry aged GMP chiller temperature (-0.5-1.0°C)*	2+C=**8** **CCP1 – Chilled storage**
		Incorrect relative humidity control	Relative humidity to be 85% - 75%	4+D=21 **CP3 – Relative humidity**
		Incorrect airflow and product to product contact	Dry ageing operational GMP	4+D=21 **CP4 – Air flow**
		No use of UV lights	UV lights in use and bulbs replaced on 6 month cycle	4+D=21 SP
	Chemical: Nil identified			
	Physical: Nil identified			
5	**B**iological: Cross Contamination of micro-organisms	Trimmed off cuts come into contact with finished product	Dry ageing operational GMP	3+C=13 SP

Trim		Contamination from staff, premises or equipment	GMP hygiene & sanitation.	3+D=17 SP
	Biological: Growth of pathogenic micro-organisms	Product temperature increase during processing	Product to be processed in a temperature controlled environment of <10°C without delay	2+D=**12** **CP2 – Processing room temperature**
	Chemical: Nil identified			
	Physical: Nil identified			
6 **Cutting**	**B**iological: Cross Contamination	Trimmed off cuts come into contact with finished product	Dry ageing operational GMP	3+C=13 SP
		Contamination from staff, premises or equipment	GMP hygiene and sanitation.	3+D=17 SP
	Biological: Growth of pathogenic micro-organisms	Product temperature rises during processing	Product to be processed in a temperature controlled environment of <10°C without delay	2+D=**12** **CP2 – Processing room temperature**
	Physical : Metal contamination	Metal contamination from bandsaws or equipment	Metal detection	2+D=**12** **CP5 – Metal detection**
	Chemical: Nil identified			
7 **Packaging**	**B**iological: Cross Contamination	Contamination from staff, premises or equipment	GMP hygiene and sanitation.	3+D=17 SP
	Biological: Growth of micro-organisms	Product temperature rises during processing	Product to be processed in a temperature controlled environment at <10 °C without delay	2+D=**12** **CP2 – Processing room temperature**
	Physical: Nil identified			
	Chemical: Nil identified			
8	**B**iological: Growth of pathogenic micro-organisms	Product temperature increases during storage	Temperature control. Maintain meat temperature <5^{o}C	2+B=**5** **CCP1 – Chilled Storage**

Storage		Product past shelf life	Stock control – product traceability Labelling	3+D=17 SP

2.4 HACCP Audit Table

The following table identifies the CCP and CP critical limits for the dry age process and suggests monitoring corrective action procedures. Processors need to use a trained HACCP Co-ordinator to develop an audit table suitable for their hazard analysis and identified CCP's and CP's.

Table 4. HACCP Audit Table

CCP/CP	Step	Hazard	Control measure	Critical Limit	Monitoring	Corrective Action	Records
CCP1	Chilled Storage	Biological: Growth of pathogenic micro-organisms	Maintain chiller temperature <5°C.	Chiller temperature of <5°C. This critical limit is set to maintain product temperature <5°C. Validation is required for each chiller.	**What**: Chiller temperature <5°C **How:** Computer or manual reading using calibrated thermometer **Where:** Chiller or computer **When:** Checked 2x daily **Who:** Trained food safety officer	Move product to active chilling.	Chiller temperature record or daily processing record
CP1	Receival Temperature	Biological : Excessive microbiological load/growth on incoming meat	Raw material received from supplier at <5°C	Product temperature measured to be <5°C.	**What:** Product temperature <5°C **How:** Insertion of calibrated thermometer probe into meat **Where:** At point of receival **When:** Each load **Who:** Trained food safety officer	Reject product >5°C	Product receival record
CP2	Processing Room Temperature	Biological: Growth of pathogenic micro-organisms	Maintain processing room temperature <10°C.	Room temperature of <10°C.	**What:** Room temperature <10°C **How:** Computer or manual reading using calibrated thermometer **Where:** Room or computer **When:** Checked 2x daily **Who:** Trained food safety officer	Move product to active chilling immediately. Rectify refrigeration issue before continuing processing.	Room temperature record or daily processing record
CP3	Dry Age Storage - Relative Humidity	Biological: Growth of pathogenic and spoilage micro-organisms	Maintain chiller relative humidity lower than normal holding chiller.	Chiller relative humidity ≤85%.	**What:** Chiller relative humidity **How:** Computer or manual reading using calibrated meter **Where:** Meter or computer **When:** Checked 1x daily **Who:** Trained food safety officer	Rectify relative humidity issue as soon as possible. Issue to be repaired within 48 hours.	Daily processing record.
CP4	Dry Age Storage – Air Flow	Biological: Growth of pathogenic and	Product not touching to allow air flow	Nil product to product touching	**What:** Nil product touching **How:** Observation of all product **Where:** Dry age chiller	Separate any touching product	Daily processing record.

		spoilage micro-organisms			**When:** Checked 1x daily **Who:** Trained food safety officer		
CP5	Metal detection	Physical: Metal contamination from bandsaws or equipment	Use metal detector	* Nil detection as per metal detection sensitivities	**What:** Metal detection **How:** All product to go through metal detector **Where:** Processing area **When:** 100% of product, test detector with test pieces prior to start **Who:** Trained operator	Identify affected product and dump if metal contamination cannot be removed. Repair equipment where metal contamination originated.	Daily processing record or metal detection checksheet

3. Good Manufacturing Practice – Dry Aged Beef

The Good Manufacturing Practice (GMP) guidelines have been developed to assist processors with the production of dry aged beef. A processor of dry aged beef must identify the food safety risks in their process and manage them appropriately. It is also advisable to determine what conditions best suit the required finished product quality and validate that these meet food safety requirements.

3.1 Procurement of Raw Material

Procure from approved suppliers that have HACCP certification.

Procure and receive beef within 5 days of slaughter if possible.

If chiller relative humidity and air flow conditions cannot be tightly controlled (see section 3.5.2) it may be preferable to receive meat vacuum packed to inhibit exposure to yeast and mould during the transport process.

- *Use a raw material specification sheet for procurement. Specification to detail maximum age on delivery and packaging requirements.*
- *Purchase order and receival details retained for traceability.*

3.2 Acceptance of Raw Material

All raw materials received for the dry age process are sourced exclusively from approved suppliers. Inward goods are checked for compliance with these specifications upon unloading.

Product received must be at a temperature <5°C and be transferred immediately to refrigeration <5°C.

Product that does not meet the required specification is either rejected at the load in point or accepted and diverted to processes other than dry aging.

All products are visually inspected under light of at least 600 lux for defects.

- *Receival details recorded on QA form*

3.3 Initial (Pre-Dry Age) Storage

Products are stored prior to commencing the dry age process to ensure all products are at the desired temperature of <5°C prior to being un-packed, placed on racks, identified and placed into the dry age chiller. Ideal pre-ageing storage temperature is <2°C.

Product is stored in refrigeration in a manner which ensures adequate air flow around cartons or product.

Initial storage period should not exceed 24 hours.

- *Chiller and product temperatures are checked and recorded on GMP checklist form daily*
- *Chiller temperatures are constantly monitored and logged on the refrigeration software or manually.*

3.4 Un-pack, Identify and Transfer Product to Dry Age Chiller

Products are removed from initial storage for unpacking and preparation for dry aged storage. The volume of products removed from active refrigeration is determined by factors that influence product flow. Points considered to ensure steady product flow and reduced time out of active refrigeration include:

- Staffing levels
- Work time available between breaks
- Quantity of cuts or pieces to be processed in the available time

All products are visually inspected under light of at least 600 lux for defects. Defects include visible contamination (biological or physical).

Preparation area to be away from possible airborne contaminants and be cleaned and sanitised immediately prior to use.

Procedures are to be performed by trained staff in a closed refrigerated environment. The work room is kept at a temperature of no more than 10°C. Ideal temperature would be <5°C.

Product is assessed for quality parameters such as colour, DFD and fat coverage. The cutting lines of the primal are also inspected to ensure slashes are not present and the muscle is in good condition.

The tables and other equipment used during this process are subject to pre operational hygiene checks. They are to be positioned within the room in a manner which ensures outer packaging (cartons) and primary packaging (vacuum bags) are removed immediately to a position that eliminates the risk of contact with un-packaged raw material.

Uniforms worn by staff working within this processing area are colour coded to ensure those handling potentially contaminated materials (cartons/packaging etc.) are not handling raw material. For smaller operations a change of PPE and personal hygiene procedures should be carried out.

Staff working in other areas of the plant are not permitted entry into this area without performing full personal hygiene procedures including change of protective clothing and sterilising tools and PPE.

Products are positioned on racks in a manner which ensures no product to product contact occurs and all pieces are parallel to assist in adequate air flow.

Pieces or batches are labelled either by tying a string around the outer surface of the piece which in turn has a label attached or by labelling trolleys or shelving containing product. Labelling material must not be a potential source of contamination. Label information includes:

- Date the dry aging process commences

- Batch code (includes supplier details and packing date)
- Trade description

Ensure products are not cut with a knife or pierced with a needle to attach string or labels. Products are not to be mechanically needled or injected as this will compromise the wholesomeness of the product.

Racks are placed into the dry age chiller and rotation of trolleys/shelving within the chiller is performed on a weekly basis.

- *Product temperatures and correct performance of procedures as per work instructions are recorded on GMP checklist form twice daily.*
- *Work room temperatures are constantly monitored and logged on the refrigeration software or manually.*

3.5 Dry Ageing

3.5.1 Chiller structure

Chiller walls should be made of impervious materials.

Seals on doors should inhibit ingress of moisture, warm air and possible airborne contamination.

Floors should be designed to inhibit the pooling of water.

Racks or shelving should be made of stainless steel and ideally be mobile or removable for cleaning purposes.

Standard lighting should be sufficient for viewing all product in the chiller.

3.5.2 UV Lighting

The dry age chiller is fitted with UV lights at a suggested density of 1 unit per $5m^2$. The UV light units are positioned strategically to have the most effect on:

- Air leaving the evaporator
- Air returning to the evaporator
- Direct product surfaces
- Reduce product ‘shading’ as much as practicable

The UV lighting is activated by a mechanical electrical switch which is placed on the door frame at ceiling level to avoid damage and reduce the risk of having staff forgetting to activate lights when closing the room. Other sources of light are disabled whilst the chiller door is closed.

The UV light units are serviced according to the maintenance schedule and at intervals of 6 months. The service includes cleaning protective covers and changing of tubes regardless of tube performance.

- *Details of maintenance activities are recorded on GMP checklist form X and maintenance schedule form*

3.5.3 Air Flow and Relative Humidity

Evaporators fitted within the chiller are designed to effect humidity through variable fan speed and coil to ambient temperature settings. Target relative humidity range is 75-85%.

A minimum air speed of 0.2m/s is required; target range is 0.2m/s to 0.5m/s. An increase of the air speed above the target 0.5m/s will have an effect on yield however not on product wholesomeness.

If possible position new product in the highest air flow to develop early crust formation which assists with reducing water activity and therefore restrict fungal and bacterial growth.

Maintenance of the evaporator is scheduled six monthly and includes checking:

- Performance of defrost
- Fan blade condition
- Fan motor condition including amperage draw and bearing condition
- Protective covers and cleanliness
- Coil cleanliness and impediments to air flow

3.5.4 Chiller and Product Temperature

Evaporators fitted within the dry age chiller are designed to maintain constant chamber air temperatures at times of loading and unloading.

The required chiller air temperature to meet food safety requirements is <5°C. The target chiller temperature for dry ageing is 0.5°C.

Refrigeration equipment utilised such as variable speed compressors, electric defrost units and electronic thermal expansion (TX) valves ensure variances from the target temperatures are minimised.

Ensure chiller conditions do not cause condensation or drip on to product.

- *Chiller and product temperatures are checked and recorded on GMP checklist form daily*
- *Chiller temperatures are constantly monitored and logged on the refrigeration software or manually.*

3.5.5 Ageing Time

Ageing time will dictate evaporative yield loss and flavour development. Validation of required ageing time to develop customer flavour requirements is suggested.

If chiller conditions are constantly monitored and maintained as per the above set points there should be minimal visible microbial growth. Upon the appearance of visible mould, yeast or bacterial growth, remove the affected portions and trim as per guideline 3.6.

Recommended minimum ageing time to develop flavour profile is 14 days.

3.5.6 Salt Wall

Salt is hygroscopic and therefore can remove moisture from the air. Salt blocks are not necessary in a large scale commercial chiller that has refrigeration units capable of maintaining relative humidity <85%.

On a smaller retail/display scale salt blocks may be of benefit to reduce relative humidity.

Salt blocks are sometimes used for marketing purposes. Himalayan salt blocks are traditionally used.

Note that salt blocks deteriorate over time and will need to be replaced.

3.6 Finished Dry Age Product Trimming and Packing

Finished dry aged products are removed from dry aged storage for trimming and preparation for the packaging process.

The volume of products removed from active refrigeration is determined by factors which influence product flow. Points to consider ensuring steady product flow and reduced time out of active refrigeration include:

- Staffing levels
- Work time available between breaks
- Quantity of cuts or pieces to be processed in the available time

All products are visually inspected under light of at least 600 lux for defects.

Procedures are to be performed by trained staff in a closed refrigerated environment. The work room is kept at a temperature of no more than 10°C. Ideal temperature would be <5°C.

Uniforms worn by staff working within this processing area are colour coded to ensure those handling potentially contaminated materials are not also handling finished product. For smaller operations a change of PPE and personal hygiene procedures should be carried out.

Staff working in other areas of the processing facility are not permitted entry into this area without performing in full personal hygiene procedures including change of protective clothing and sterilising PPE.

The tables and other equipment used during this processing area are subject to pre operational hygiene checks and are positioned within the room in a manner which ensures a constant single-directional flow to reduce the risk that potentially contaminated trimmings do not come into contact with finished trimmed product.

Trimmings are removed immediately and placed in inedible products containers marked with a red band for easy identification and segregation from finished product. Trimmings are discarded as waste.

Finished products are placed on trays and immediately transferred to the packaging area. Each batch identification details are transferred to the packaging area to ensure accuracy in labelling.

Validation of shelf life of packed products both vacuum packed, gas flushed or tray packed is required.

Label products are per the FSANZ Food Standards Code labelling standard Part 1.2. For dry aged product it is important to the following items are stated on the label.

- Product description
- Shelf life
- Cooking requirements

- *Product temperatures and correct performance of procedures as per work instructions are recorded on GMP checklist form twice daily.*
- *Work room temperatures are constantly monitored and logged on the refrigeration software or manually.*

3.7 Thermometers/Relative Humidity Probes

All equipment used to monitor processing (including receival) must be checked for accuracy and calibrated regularly. Equipment relevant to the dry age process includes:

- Thermometers – hand held, data logging and fixed room chiller probes
- RH probes – Data Logger, fixed room probes

Each probe is identified and labelled for calibration verification purposes. Separate hand held thermometers are used for each area i.e. load in, storage chiller, dry age chiller, packing room.

Calibrate working thermometers (e.g. hand held thermometers) every month at refrigeration temperature.

A reference thermometer (Mercury in glass type) calibrated by a NATA accredited laboratory is used and certification carried out annually. This is used only for calibrating working thermometers.

Data logging information that is stored on the refrigeration control computer is down-loaded routinely and reviewed.

- *Calibration details recorded on QA form*

3.8 Chiller Cleaning

Cleaning of chillers should be scheduled based on size, use and product rotation. It is desirable to maintain beneficial microbiological flora and therefore ‘over’ cleaning should be avoided.

Weekly:

- Dry clean floor, pick up solids. Do not use water as this affects the relative humidity of the chiller.

- Assess chiller conditions.
    - Smell – Dry ageing meat has a characteristic fatty musty smell. UV lights give an 'ozone' odour. There should be no mould or rotting meat odours
    - Visual – Are there any indications of mould growth on chiller units, walls and ceilings? Is there any excessive mould growth on product?
    - Rectify issues using the below procedures.

As needed:

- If possible, perform cleaning when stocks are depleted or low so stock does not need to be held in an alternative location. If stock does need to be held ensure it cannot be contaminated by other product or environments.
- Remove stock from chiller.
- Dry clean floor, pick up solids.
- Turn chiller fans off to restrict formation and circulation of aerosols.
- Spot clean dirty or contaminated area using limited quantities of cold water and chemical detergent in doses as recommended by supplier ensuring sufficient contact time is allowed. For removal of fat, use warm water using a bucket (to restrict the formation of aerosols).
- Apply a no rinse quaternary sanitiser and allow sufficient contact time.
- Dry all moisture from walls, ceilings and floor.
- Turn chiller fans back on and ensure the chiller returns to the required temperature and relative humidity before returning stock. Do not return stock with heavy fungal contamination.

3.9 Chiller Fogging

If you experience ongoing growth of unfavourable fungi either on your product or in the chiller, fogging may assist with removing contamination from refrigeration units and hard to reach places.

The principle of fogging technology is to use equipment that supersaturates the atmosphere with an antimicrobial disinfectant fog of very fine droplets (10 – 20 µm in size). This allows droplets to reach areas that cannot be accessed with chemicals via foaming, splashing, scrubbing and the like.

Antimicrobial agents in liquid form are atomised and released into the air. The natural airflow in the room carries these droplets through the atmosphere and brings them into contact with areas such as evaporator fins, inside surfaces of fan blades, tiny openings and gaps in insulated panelling and angle trims, behind door rollers and tracks and most importantly into all areas which the airflow contacts.

The equipment necessary depends on the chamber volume to be covered. For chambers with a volume of >200m^3 a built-in system will be most effective. Chambers with a volume of <200m^3 will be sufficiently treated by using a mobile unit.

The chemical used in fogging machines needs to be aligned with the target microbes.

Under typical conditions, fogging is carried out for a minimum of 15–30min to enable the fog to disperse and the chemical action to occur. After fogging, an additional period of 45–60min is required to allow the droplets to settle onto the surfaces.

Fogging is not as effective in the cleaning of under surfaces as other methods such as turning tables upside down and scrubbing.

4. Finished Product Specification

An example of a generic finished product specification for a dry aged beef shell loin is located in the appendix. There are critical items that must be specified to ensure the customer is adequately informed of the food safety controls pertaining to dry aged product. These critical items are:

1. Product description – i.e. 'Dry Aged'
2. Intended use/Customer preparation
3. Portioned product shelf life

4.1 Shelf Life

The shelf life of a portioned dry aged product will be determined by how hygienically the trimming and cutting process has been completed and the method of packaging.

Dry aged beef is at its ideal consumption state after the primal has been trimmed and portioned post dry ageing. Purveyors must validate their presentation process and storage time but it is recommended that presentation of dry aged steaks in a display cabinet should be no longer than 48 hours.

For wholesalers that vacuum pack dry aged steaks the storage shelf life may be longer. Vacuum packing may cause the growth of anaerobic spoilage bacteria that could influence the final flavour of the product. Therefore extended storage periods in vacuum packaging is not recommended.

Transport of finished dry aged primals and steaks must be carried out in a manner that does not cause contamination of the product.

References

Meat & Livestock Australia, - Guidelines for the Safe Retailing of Meat and Meat Products (2012)

Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption. (AS4696:2007)

For further reading:

Savell, J.W. (2008) Dry-aging of beef, executive summary. U.S. National Cattlemen's Beef Association. http://beefresearch.org/CMDocs/BeefResearch/Dry%20Aging%20of%20Beef.pdf

Meat and Livestock Australia - Meat Technology Update 2/10 (2010) Dry Ageing Beef http://www.meatupdate.csiro.au/data/MEAT_TECHNOLOGY_UPDATE_10-2.pdf

PRODUCT SPECIFICATION	**DRY AGED BEEF SHELL LOIN**	
Product Code:	**Doc version #:**	**Approved by:**
Product Description	**Unpackaged beef shell loin is dry aged by storage in a temperature and humidity controlled environment for at least 3 weeks. Product is delivered whole and un-trimmed for customer display purposes. Complete trimming of the dry crust and cooking is required prior to consumption.**	
Raw Material Specification	Primal Cut:	Beef Shell Loin – Derived from the 3 rib shortloin by complete removal of the tenderloin
	Grade:	*YG*
	Fat thickness:	Target 10mm
Process Specification	Maximum time from slaughter to dry age storage : 5 days	
	Minimum Ageing:	21 days dry ageing
Allergen Statement	Nil	
Packaging	Immediate:	Clean, dry, cheesecloth or stockinette
	Inner:	Plastic carton liner
	Outer:	Bulk packed in cardboard carton, base and lid
	Weight:	Catch weight
Labelling	- Company and establishment details - Date of Packaging - Best Before date - Net weight - Product Description - Storage conditions - Cooking statement	
Method of Preservation - Supplier	Store below 5°C	
Method of Preservation and Preparation - Customer	Whole primal: Remove from cheesecloth and store below 5°C. Maintain display cabinet relative humidity below 85% to maintain a dry crust and restrict fungal growth.	
	Steaks: In an area separate from other food preparation remove the cheesecloth from the primal upon receival. Trim primal of dry crust including fat. Discard all trimmings to waste. On a clean cutting table with a clean knife, cut steaks as required. Display steaks on a clean tray at a temperature of less than 5°C.	
Intended Use/Customer Preparation	**Store steaks in refrigerator at less than 5°C. Consume within 48 hours of purchase*.** **Product must be cooked to an <u>external</u> temperature of +73°C for at least 1 minute.**	
Shelf Life	Whole Primal: If maintained at a temperature of less than 5°C in a cabinet with a relative humidity of less than 85% further dry ageing can be performed. Suggested maximum hold time is 10 days.	
	Steaks: At less than 5°C maximum display time is 48 hours * ***(validate for your process).***	
Delivery	In clean refrigerated trucks at <5°C.	
Country of Origin	Made from 100% Australian beef	

	The information contained HEREIN and any attachment hereto is privileged and confidential, and is intended only for the use of the recipient and others who have been specifically authorised to receive it. Produced By: Contact Details:

*The product shelf life once purchased by a retail customer depends on your process as well as theirs. It is best to validate this process taking into consideration slight temperature abuse due to your customers handling.