Brussels, 1st June 2026
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Shelf-life assessment for meat from ungulated animals – Examples of methods

Introduction and background

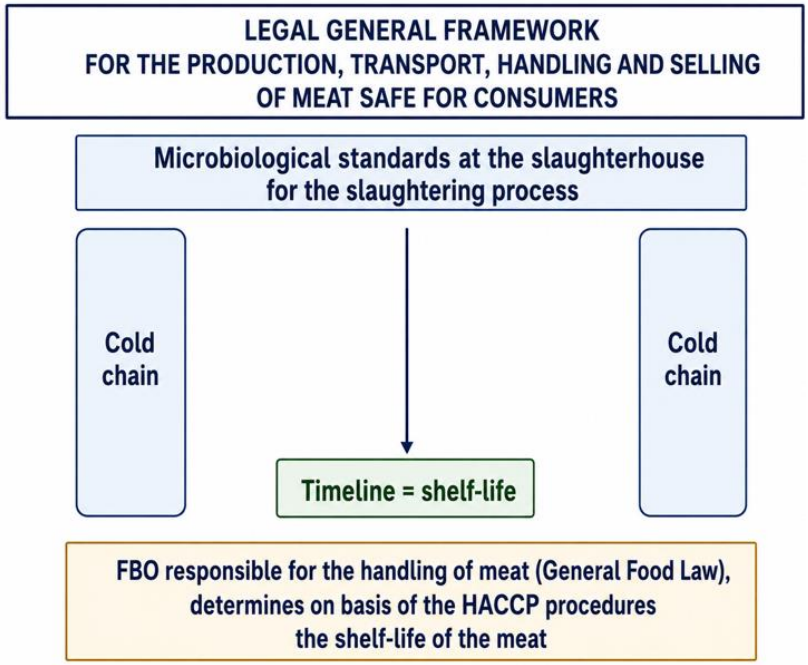
Following discussions held with the European Commission regarding the "Frozen Meat" dossier and the assessment of the shelf-life of fresh meat on 23rd April 2026, UECBV has collected practical information on current industry practices addressed to assess or validate the shelf-life of meat. The collection aimed to provide the Commission with an overview of the methodologies currently applied across the sector for assessing the shelf-life of fresh meat of domestic ungulates, by providing practical examples.

The assessment of the shelf-life of fresh meat of domestic ungulates is an integral part of an FBO's food safety management system based on HACCP principles and is currently implemented through a wide variety of operational approaches across the meat sector.

In order to understand the differences in the determination of the shelf-life, it is important to understand the framework in which the FBO's are operating, which has been developed over the years by scientists, the meat supply chain, and the legislator:

- It all starts at the slaughterhouse level, where legal standards have to be fulfilled at the carcass level.
- FBO's can choose different temperature levels for their products within the limits required by the food hygiene regulation. The temperature line and the choice regarding absence or presence of oxygen, are amongst other elements of importance in the determination of the shelf-life. The buyer of the product must ensure that these requirements are respected during storage and transport to achieve the expected shelf-life.

The meat supply chain may include traders, processors, and different destinations to be considered in the determination of the shelf-life. It is also important to understand that an FBO in the supply chain is buying a product with a history of an assessed shelf-life and storage conditions. Each FBO in the value chain may decide whether to assess the shelf-life or not, depending on the experience and relationship history with their suppliers.



The assessment of the shelf-life of fresh meat of domestic ungulates is currently implemented through a wide variety of operational approaches across the meat sector.

In practice, there is a substantial diversity regarding:

- the frequency of shelf-life assessments,
- the microbiological and organoleptic parameters monitored,
- the acceptance criteria applied,
- and the methodologies used to verify product shelf-life.

Operators combine food safety pathogens, process hygiene indicators, spoilage-related microorganisms, and sensory evaluation according to product characteristics, packaging systems, storage conditions, and individual risk management strategies. Shelf-life assessment practices frequently integrate both microbiological and organoleptic considerations, reflecting the multifactorial nature of fresh meat spoilage and product acceptability.

Operators rely on a plurality of reference systems, including Regulation (EC) No 2073/2005, national guidance values, internal company criteria, and product-specific validation protocols. This demonstrates that existing shelf-life assessment practices are already based on flexible and risk-adapted approaches developed according to the operational realities of different businesses and product categories.

Overall, shelf-life assessment within the meat sector may differ due to the diversity of approaches identified across the industry, which reflects the product-specific, process-specific, and risk-based nature of shelf-life determination in practice.

Practical examples

Meat from domestic ungulated animals is a natural food product that has not undergone decontamination treatment, except when FBOs of slaughterhouses use the provisions laid down in Regulation 101/2003 *concerning the use of lactic acid to reduce microbiological surface contamination on bovine carcasses*; therefore, a natural and diverse microbial flora develops on the surface of the meat. Microbial balances are influenced by a variety of parameters related to the product's history (the animal itself, slaughtering conditions, processing facilities through which the product is elaborated, possible temperature fluctuations, and packaging with O_2 or not). The absence of oxygen extends shelf life and selects for microbial flora different from those that develop in the presence of oxygen.

- Nearly all FBOs in the EU take organoleptic characteristics into account when validating shelf life.
- These characteristics may be associated with microbiological criteria, which provide useful information but are not the sole basis for decisions regarding the validation of meat shelf life. This is fully understandable because scientific studies show that there is no systematic correlation between the level of certain bacteria and spoilage.
- These microbiological criteria fall into three categories:
    - Measurement of spoilage flora
    - Measurement of process hygiene flora
    - Measurement of pathogenic flora
- The choice of flora depends on:
    - The historical practices in different countries, as well as the orientation given by Member State authorities (for example, competent authorities may require FBOs to measure microbial growth in order to validate shelf-life). Some countries have collective guidelines to support shelf-life validation, while others do not.
    - The stage of product processing (primary, secondary, tertiary cutting, etc.).
    - The product packaging method (mainly whether oxygen is present or absent, as this promotes or inhibits the growth of certain flora).
    - Storage temperature (which is also a fundamental parameter).
    - Animal species (has an impact on the development of certain bacterial subspecies and the interactions between them)

- Microbiological assessment of products' shelf-life performed by FBOs generally relies on microbiological analyses for initial validation, microbiological growth trials, or application of predictive models (e.g. DMRI), that may not cover all animal species.
- It should be noted that the limiting factor for validating microbiological shelf lives is spoilage flora (see EFSA opinion, which only considered modelling).
- The microbiological analytical methods used to measure criteria such as aerobic mesophilic flora, lactic flora, and Enterobacteriaceae are variable and may be imprecise:
    - Since these methods group together several bacterial families, depending on the balance established between these bacterial families, microbial counts increase more or less rapidly until reaching a plateau.

- These methods are useful at the slaughterhouse chilling stage because they indicate the initial bacterial load, but their interpretation should be approached with caution when considering downstream stages of the food chain.
- Depending on the temperature used in the analytical method (where there is sometimes a choice), results differ.
- Methods designed to obtain results more quickly are carried out at temperatures of 25°C or 30°C, but are not carried out under product storage conditions at 4°C; the same flora are selected to determine whether the same growth patterns occur.
- These are general methods applicable to all foods and are rarely specific to meat.

In order to illustrate the different methods for assessing and/or validating the shelf-life of meat performed by stakeholders, the following examples have been collected as appendices to this document:

1. **Pork example – FBO own control programme** (document 33168). Combines micro-criteria and sensory parameters for assessing the shelf-life of different pig products (lean meat, offal, blood, etc). Packing is also considered.
2. **Sensorial criteria – FBO own control programme** with the purpose of ensuring that products are sensory suitable for sale in retail and wholesale throughout the shelf life (document 33118). Actions to be taken in case of non-satisfactory results are also described.
3. **Beef and Veal – FBO own control programme** (document 33117): illustrates how the company must document how long its products may remain in a quality that meets the company's standards for texture, colour, and taste, including complying with the legal requirements for microbiological criteria. The method is supported based on DMRI shelf-life prediction model.
4. **Maturation of beef.** Danish Meat Research Institute. Machine translation from Danish (document 33116)
5. **Microbiological reference** and warning values for the assessment of foodstuffs (DGHM) – Germany (33164)
6. **Validation of shelf-life** of chilled retail-packed rump joints from beef rump primal frozen after fresh chilled maturation (document 33120) **– FBO own control programme**
7. **Validation of Fresh Retail Vacuum-Packed Lamb Rump** (document 33121). The scope of this validation is the use of vacuum packaging for fresh lamb rump steaks, with consideration of customer freezing and domestic handling. Lamb rump steaks packed in skin packed trays were evaluated to support extension of fresh shelf life to pack plus 19 days (P+19). **– FBO own control programme**

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Annex I Pork [redacted]

Product group	Shelf-life	Analyses	Limits	Remarks
Lean meat with 80/20, 70/30 or 90/10 ratios	Slaughter + 5 days	Listeria count	< 100 CFU/g	
		Salmonella per 10 g	Not detected in 10 g	
		E. coli	< 500 CFU/g	
		Aerobic colony count	Log 7.0 CFU/g	Indicator
		Enterobacteriaceae	< Log 4.0 CFU/g	Indicator
		Lactic acid bacteria	Log 7.0 CFU/g	Indicator
		Sensory evaluation	No abnormalities	Sensory assessment

Product group	Shelf-life	Analyses	Limits	Remarks
Fresh meat	Slaughter + 6 days	Listeria count	< 100 CFU/g	
		Salmonella per 10 g	Not detected in 10 g	
		E. coli	< 500 CFU/g	
		Aerobic colony count	< Log 7.0 CFU/g	Indicator
		Enterobacteriaceae	< Log 4.0 CFU/g	Indicator
		Odour	No abnormalities	Sensory assessment
		Colour	No abnormalities	Sensory assessment

Product group	Shelf-life	Analyses	Limits	Remarks
Vacuum-packed meat (vacuum-packed muscle cuts)	Slaughter + 18 days	Listeria count	< 100 CFU/g	
		Salmonella per 10 g	Not detected in 10 g	
		E. coli	< 500 CFU/g	
		Aerobic colony count	< Log 7.0 CFU/g	Indicator
		Lactic acid bacteria	< Log 7.0 CFU/g	Indicator
		Enterobacteriaceae	< Log 4.0 CFU/g	Indicator
		Odour	No abnormalities	Sensory assessment
		Colour	No abnormalities	Sensory assessment after 30 minutes outside packaging

Annex I Pork [redacted]

Product group	Shelf-life	Analyses	Limits	Remarks
Frozen products	Slaughter + 2 years	Listeria count	< 100 CFU/g	
		Salmonella per 10 g	Not detected in 10 g	
		E. coli	< 500 CFU/g	
		Aerobic colony count	< Log 7.0 CFU/g	Indicator
		Enterobacteriaceae	< Log 4.0 CFU/g	Indicator
		Rancidity	< 3 Meq/kg fat	
		Odour	No abnormalities	Sensory assessment
		Colour	No abnormalities	Sensory assessment

Product group	Shelf-life	Analyses	Limits	Remarks
Bacon	Slaughter + 42 days	Listeria count	< 100 CFU/g	
		Salmonella per 10 g	Not detected in 10 g	
		E. coli	< Log 3.7 CFU/g	
		Aerobic colony count	< Log 7.0 CFU/g	Indicator
		Enterobacteriaceae	< Log 4.0 CFU/g	Indicator
		Odour	No abnormalities	Sensory assessment
		Colour	No abnormalities	Sensory assessment

Product group	Shelf-life	Analyses	Limits	Remarks
Organs/offal	Slaughter + 6 days	Listeria count	< 100 CFU/g	
		Salmonella per 10 g	Not detected in 10 g	
		E. coli	< 500 CFU/g	
		Aerobic colony count	< Log 7.0 CFU/g	Indicator
		Enterobacteriaceae	< Log 4.0 CFU/g	Indicator
		Odour	No abnormalities	Sensory assessment
		Colour	No abnormalities	Sensory assessment

Product group	Shelf-life	Analyses	Limits	Remarks
Blood	Slaughter + 2 days	Salmonella per 10 g	Not detected in 10 g	
		E. coli	< 5,000 CFU/g	
		Aerobic colony count	< Log 7.0 CFU/g	Indicator
		Enterobacteriaceae	< Log 5.0 CFU/g	Indicator

10.5.1.1

Durability tests – packaged products

Purpose
Ensure that products are sensory suitable for sale in retail and wholesale throughout the shelf life.

Frequency
Appears from analyses and finished product control - matrix.
Samples are taken from different product types and fat categories to ensure that the shelf life is controlled in the different product types.

Acceptance limit
Sensory is assessed based on a scale:

- Satisfactory (The product has not changed significantly compared to a fresh version)
- Acceptable (The product has undergone an expected quality change but is OK and suitable for eating)
- Unsatisfactory (The product has distinct quality deficiencies and is unfit for consumption)

	Satisfactory	**Acceptable**	**Unsatisfactory**
Sensory assessment **Final Durability**	No follow-up	Products rated yellow are included in trend analysis	Review of *- Raw material quality* *- Storage temperature* *- Manufacturing hygiene* *- Take out a new set*

The laboratory makes analyses based on the following table:

Appearance		**Smell**	
U1	Gray/brown appearance	**L1**	Sour smell (beyond the naturally expected one)
U2	Uneven/area-specific discoloration	**L2**	Acidic smell
U3	Faded	**L3**	Sweet smell
U4	Slimy	**L4**	Pig smell (pork only)
U5	Liquid extraction in the tray (a lot)	**L5**	Spoiled
U6	Visible growth	**L6**	Salty smell
		L7	Metallic
		L8	Unclean smell
		L9	Heavy warm smell
		L10	Cardboard smell

Procedure

The samples are taken during production.

Created electronically in LIMS (XX laboratory) - see request no. and spec. no. in procedure" Analyses and finished product control - matrix", label and attach delivery note.

Samples are sent to the laboratory as soon as possible and under refrigerated conditions. Storage temperature, see product labeling.

Responsible
Self-control Manager

Documentation
Results are continuously recorded on the relevant laboratory form in SharePoint. The in-house control manager is responsible for monitoring, evaluating and approving analysis results.

Remedial action
In case of unsatisfactory results, a report is prepared and the procedure for handling deviations is followed.

Version	1.2
Commissioning date	29.09.2025
Responsible	XX
Approval Committee	XX

Purpose/scope

The company must document how long time the company's products can remain in a quality that meets the company's standards for texture, color and taste, including complying with the legal requirements for microbiological criteria.

New products

When producing new products, packages are taken from the trial production to test the durability throughout the shelf life. The products are sensory evaluated.

Responsibility

	Sampling	Sensory assessment and determination of any new shelf life.	Submission of samples
Administrative employee Farsoe	x		x
Quality department		x	

Description

The company must document how long time the company's products can remain in a quality that meets the company's standards for texture, color and taste, including complying with the legal requirements for microbiological criteria.

Pre-packaged beef or veal for sale as fresh

The shelf life is verified by submitting products for analysis at the best-before date to ensure that the products are still fresh, as well as conducting a sensory assessment and possibly a taste test.

When assessing meat cuts and by-products that require extended shelf life, the products are packaged and stored at the specified temperatures and then sensory assessed (visually, smell and possibly roast test) internally at the company.

To help determine durability, DMRI's predictive mode are also used: DMRI

Testing of products is carried out by the Farsoe department.

Beef and veal, fresh meat and labelling for later freezing

Freezing of meat must take place shortly after slaughter (authorized wholesalers or retailers with wholesaing). This means that it is not permitted to freeze the meat at the end of the shelf life.

Freezing fresh meat must take place no later than the end of the maturation period.

The commercial document that accompanies the product states: "the end of the maturation period is stated on the box label".

The box label states the date for the "End of maturation period":

The establishment follows the recommendation: "Maturing of beef Danish Technological Institute, background 31-1-2025", see link under documentation.

The stabilization/maturation period is set at a maximum of 30 days from the date of production:

In practice, this means that beef and veal products with the longest shelf life, which is typically approximately 42 - 49 days, will be fully stabilized/matured and recommended ready for freezing after 30 days of refrigerated storage (according to a report from the Danish Technological Institute).

For products with a shorter shelf life, the end of the maturation period and thus the latest recommended time to start freezing is determined/calculated by taking the product's best-before date and subtracting 25%: For example, a product with a shelf life of 30 days will be fully matured and ready for freezing after 23 days from the production date/packaging date.

Extending shelf life

The specified shelf life can be extended. This requires a sensory assessment and possibly a taste test.

Documentation and attachments

Maturing_of_beef_-Technological_Institute_background_31-1-2025.pdf

Microbiological reference and warning values for the assessment of foodstuffs (DGHM)

Reference and warning values for raw, seasoned and marinated beef (excluding offal), 2021

	Reference value (KbE/g)	Warning Value (KbE/g)
Enterobacteriaceae	1×10^4	1×10^5
Escherichia coli	5×10^2	5×10^3
Presumptive Pseudomonas	1×10^6	-
Coagulase-positive staphylococci	$5x\ 10^2$	5×10^3
Salmonella	-	not detectable in 25g
Listeria monoytogenes	-	1×10^2

KbE = Colony-forming unit
Applies to loose or pre-packed goods!

Reference and warning values for raw, seasoned and marinated pork (excluding offal), 2021

	Reference value (KbE/g)	Warning Value (KbE/g)
aerobic mesophilic colony count*	5×10^6	
Enterobacteriaceae	1×10^4	1×10^5
Escherichia coli	1×10^2 (raw) 5×10^2 (seasoned and marinated)	1×10^3 (raw) 5×10^3 (seasoned and marinated)
Presumptive Pseudomonas	1×10^6	-
Coagulase-positive staphylococci	$5x\ 10^2$	5×10^3
Salmonella	-	not detectable in 25g
Listeria monoytogenes	-	1×10^2

KbE = Colony-forming unit
Applies to loose or pre-packed goods!
*If live microorganisms are added as starter cultures or ingredients such as yoghurt that contain live organisms, this must be taken into account in the assessment.

Reference and warning values for unseasoned and seasoned minced meat from pork and/or beef at trade level (2022)

	Reference value (KbE/g)	Warning Value (KbE/g)
aerobic mesophilic colony count*	5×10^6	
Enterobacteriaceae	1×10^4	1×10^5
Escherichia coli	1×10^2 (unseasoned) 5×10^2 (seasoned)	1×10^3 (unseasoned) 5×10^3 (seasoned)
Pseudomonas	1×10^6	-
Coagulase-positive staphylococci	$5x\ 10^2$	5×10^3
STEC/EHEC[1)]		not detectable in 25g
thermophilic campylobacter[2)]		Not detectable in 10g
Salmonella[3)]	-	not detectable in 25g
Listeria monoytogenes[4)]	-	1×10^2

KbE = Colony-forming unit
Applies to loose or pre-packed goods!
[1)]Made from beef, for raw consumption
[2)]Made from pork, for raw consumption
[3)]Statutory regulations may prescribe other test quantities.
[4)] For the examination and evaluation of Listeria monocytogenes, the requirements of Regulation (EC) No. 2073/2005 on microbiological criteria for foodstuffs in the currently valid version must be observed.

TEKNOLOGISK INSTITUT

Note

Beef maturation at the cut level – analysis

Marchen Hviid

January 31, 2025
2003889-140
Version 01
MAHD/mt

Purpose

Prepare a report in the form of a literature review of beef maturation, based on knowledge from previous industry projects, supplemented with the latest available literature in the field. The articles used are listed in the literature review at the end of the note.

Scope

- Brief technical description of the physiological background of maturation.
- Importance of raw material type (age, breed, gender and muscle).
- Importance of storage conditions during maturation (time, temperature) • Brief technical description of different principles (e.g. wet-aging, dry-aging).

Tenderness

One of the most important consumer requirements for beef is tenderness, and therefore the beef industry also wants to deliver as tender meat as possible to consumers, while ensuring that all other qualities are in order. One of the most important methods to ensure tenderness is aging after slaughter.

Physiological basis for tenderness and ripening

The physiological basis of maturation
The five main factors that have the greatest influence on variation in tenderness in beef cuts are:

- Collagen content and cross-links between collagen fibers in the muscles
- The length of the sarcomeres in the muscle cell.
- Enzymatic degradation of myofibrils in muscle cells after death-ning.
- *Intramuscular fat content (not covered in this overview)*
- *Protein degradation during heating (not covered in this overview)*

Collagen

Collagen, which is the most common type of protein in connective tissue, is a heat-stable protein, and bonds between collagen fibers increase with the age of the animal. Muscle type has a great influence on the amount of collagen, typical connective tissue-rich muscles are muscles from the forequarter, while fillet and tenderloin are muscles poor in connective tissue. Collagen bonds require heat to be broken down.

Sarcomere length

Sarcomers are the smallest unit that performs the work of contraction and relaxation in living muscle, see figure 1. It is the bonds between Actin (green) and Myosin (red) that ensure movement of the muscle. When the energy supply to the muscle stops, the bonds between the filaments are no longer loosened, and rigor mortis (rigidity of death) occurs.

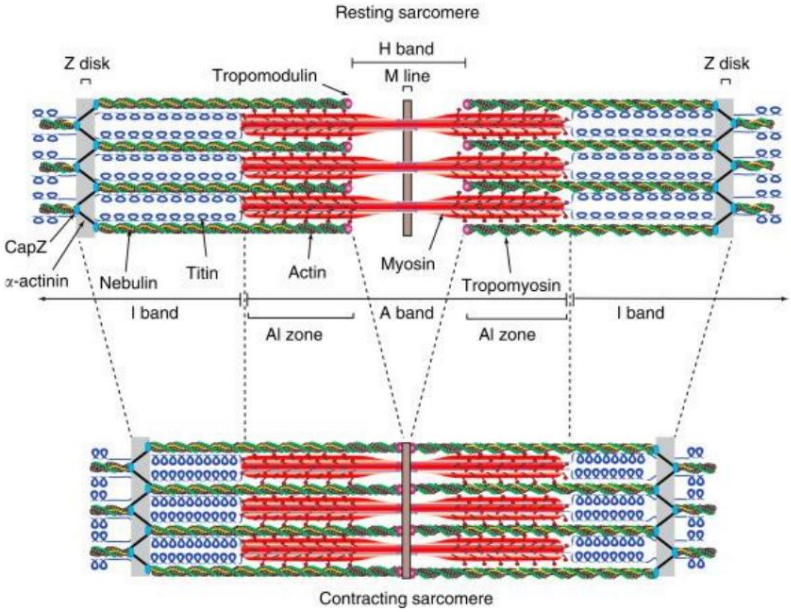

Figure 1. Sarcomeres – the smallest muscle filament, shown here in relaxed and contracted states. Source: B. Cadot, ER Gomes, in Encyclopedia of Cell Biology, 2016

Enzymatic degradation

After rigor mortis has set in, enzymatic breakdown of the protein structure in the muscle fibers begins. This breakdown with subsequent rebuilding is also active in living muscle, where the protease system calpain/calpastatin is the most important. The enzymes can be compared to scissors, which cut the proteins into smaller pieces and thus make the meat more tender, figure 2.

In particular, degradation of the cell's skeletal proteins is important for tenderness. The faster the animal has grown, the there are more enzymes in the meat, and the The faster (and more) the meat tenderizes during ripening. There are no bacteria involved (the meat does not rot).

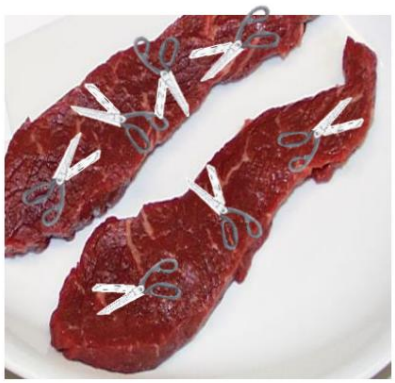

Figure 2. Maturation is an enzymatic breakdown of the proteins.

Regulation of enzyme activity

close

The activity of the proteases is mainly regulated by the level in the muscle at slaughter of the animal, the length of the maturation period, the proteases' ability to be active (time, temperature) during maturation and the amount of inhibitors to the enzymes.

Importance of factors from primary production Age at slaughter, breed, sex and transport/handling on the day of slaughter all influence how tender the meat becomes.

Race

Meat from the Holstein breed and its crosses must mature longer (>21 days) to achieve, for example, the same tenderness as meat from Limousin cattle, and the Holstein breed is very widespread in Denmark (54% of all cattle in Denmark are pure Holstein, plus crosses).

Age

Meat from young animals (calves) has a shorter maturation time than meat from older cows, and this applies to all muscles, among other things due to connective tissue differences, and because growing animals have a faster protein turnover and thus more active enzymes.

Transport/ processing

Inappropriate treatment on the day of slaughter will result in the animal's energy reserves being depleted. This will affect glycogen metabolism and thus the final pH of the meat.

The importance of pH

Tenderness development in fillet depends on the final pH of the meat, where abnormal final pH, both high and low, means more tender meat, but with an abnormal taste and texture.

Sex

The significance of gender is primarily related to the correlation between gender and fat marbling.

Importance of maturation time and temperature
Maturation should take place in refrigerated storage. The effect is greatest in the first days after slaughter, but continues up to 30 days or more from slaughter. Figure 3 shows the effect of maturation days (at 2°C) on consistency. The study was conducted on lamb, and similar results have been reported in both Danish and foreign studies on beef.

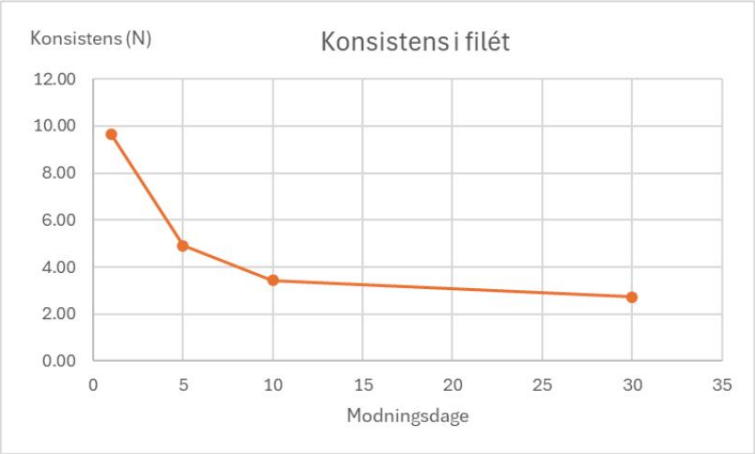

Figure 3. Relationship between consistency and ripening days. Adapted from Pearce et al. (2009). Based on fillet of lamb.

Temperature during ripening

The ripening effect is also temperature-dependent, with higher temperatures increasing enzyme activity and thus also the development of tenderness. Storage temperatures > 5°C will also affect bacterial growth and have therefore only been studied in experiments. Studies in the low temperature range (-1.5 to 5°C) however show a limited effect of temperature, and therefore the recommended temperature during ripening is 0-2°C.

Aging methods Aging

Wet aging

of beef can take place after the muscles have been cut from the carcass and vacuum-packed, which is also called wet-aging. The method was implemented in the 1970s and meant better shelf life due to less contamination, better process flow and less waste in production.
The method is the most commonly used, also during transport/export from other countries.

Dry aging

Alternatively, the muscles can remain on the carcass or only be divided, so that the bones and fat layer are preserved on the cut. The cut is not packaged, but placed in a cold room surrounded only by air, the so-called dry-aging.

Tenderness and taste

The enzymatic ripening processes proceed in the same way regardless of the ripening method, so tenderness is the same as for wet-aging. Dry-aging will also mean increased oxidation of especially the fat due to oxygen availability throughout the ripening period. This will affect the taste, and dry-aging has improved consumer liking in some studies. However, other studies have also reported no difference, or that vacuum-packed meat is preferred.

Cost of dry-aging

Dry-aging is a relatively expensive maturation method. It requires more space in the cold rooms, there is greater shrinkage during maturation, there will be a lot of trimming of dried fat and meat, and in addition there is a greater risk of contamination and growth of unwanted microorganisms, which also leads to greater shrinkage.

Challenges of dry-aging

Dry-aging also requires more control over temperature, air velocity and humidity to achieve a satisfactory end product. At the same time, it can be difficult to achieve the same end result in different studies,
even if the refrigerated displays are set the same.

Packaging for dry-aging

Various packaging materials (e.g. Tublin®) are also offered for dry-aging, which should reduce shrinkage, and several companies recommend that the pieces of meat be polished and vacuum-packed after 2-3 weeks, so that only in the first part of the maturation period is an actual dry-aging method used.

Literature/ articles

Grzegorz Pogorzelski, Ewelina Pogorzelska-Nowicka, Paweÿ Pogorzelski, An-drzej Póÿtorak, Jean-François Hocquette, Agnieszka Wierzbicka: Towards an integration of pre- and post-slaughter factors affecting the eating quality of beef. Livestock Science 255 (2022) 104795.

Peter P. Purslow, Mohammed Gagaoua, Robyn D. Warner. Insights on meat quality from combining traditional studies and proteomics. Meat science 174 (2021) 108423.

Per Ertbjerg, Eero Puolanne. Muscle structure, sarcomere length and influences on meat quality: A review. Meat Science 132 (2017) 139–152.

D. Lomiwes, MM Farouk, G. Wu, OA Young. The development of meat tenderness is likely to be compartmentalized by ultimate pH. Meat Sci-ence. 96-1, (2014) 646-651.

KL Pearce, DL Hopkins,, A. Williams, RH Jacob, DW Pethick, JK Phillips. Alternating frequency to increase the response to stimulation from medium voltage electrical stimulation and the effect on objective meat quality. Meat Science 81 (2009) 188–195.

Manuel Juárez, Ivy L. Larsen, Lorna L. Gibson, Wayne M. Robertson, Michael ER Dugan, Noelia Aldai, and Jennifer L. Aalhus. Extended aging time and temperature effects on quality of sub-primal cuts of boxed beef. Canadian Journal of Animal Science, (2010) DOI: 0.4141/CJAS09079.

Nino Terjung, Franziska Witte, Volker Heinz. The dry aged beef paradox: Why dry aging is sometimes not better than wet aging. Meat Science 172 (2021) 108355.

Lawrie's Meat Science, 9th edition. Edited by Fidel Toldrá.

New Aspects of Meat Quality – from genes to ethics. 2nd edition. Edited by Peter Purslow.

Tub-ex. Tublin®

Seges Innovation. Number of active animals per cattle breed

Validation of shelf-life of chilled retail packed rump joints from beef rump primals frozen after fresh chilled maturation.

Scope

This report summarises the validation of the retail shelf life of retail vacuum packed beef rump joints derived from intact beef rump primals frozen after fresh maturation in vacuum pack.

The purpose is to demonstrate that the process produces a safe and good quality organoleptically acceptable product that has been subject to defined worst-case consumer handling conditions.

Method

The validation utilised a structured, multi-line evidence approach combining microbiological testing and organoleptic quality assessment.

10 finished product samples were used in the validation.

The raw material, beef rump primal, was matured in a primal format in chilled conditions (<3^{o}C), in vacuum packed conditions for 21 days (cut and packed 2–5 days post-slaughter) prior to blast freezing at -18^{o}C within 24 hours. Product was then held frozen prior to tempering and subsequent conversion into a retail ready joint format.

The study framework includes defined storage stages and challenge conditions that align to current distribution and domestic handling processes by the consumer, supported by raw and cooked sensory scoring criteria.

Finished packs of were subjected to depot temperatures (2-4^{o}C), temperatures they would be exposed to within a retail setting in fridges (5^{o}C), temperature abuse the consumer would subject the product to (22^{o}C), and finally domestic storage by the consumer (8^{o}C) until EOL. FSA guidance on domestic refrigeration temperatures recommends a fridge temperature of 5C. It is noted that the average temperature for a UK domestic fridge is 4-7^{o}C. The testing in this validation have been completed based on domestic refrigeration of 8^{o}C.

In summary

- Kill date (K)
- Carcases held in chills for 2-5 days at 0^{o}C +/- 1^{o}C
- Cut and vacuum packed at K+2-5 days

- Blast frozen within 24 hours of cutting and packing P+1
- Frozen at -18°C for 21 days
- Tempered to chilled at P+21 days, P+21-24 days
- Tempered primals then cut into retail joint cuts and packed in retail joint format, stored at <3°C
- Then exposed to
    - 2-4°C to mimic being held in depot
    - 5°C to mimic a retail display fridge
    - 22°C to mimic consumer temperature abuse
    - 8°C until end of life (EOL) to mimic consumer domestic storage

Microbiological testing was completed on samples at the start and end of the retail life, and included both *E.coli* (generic), *E.coli O157*, and *Salmonella* spp..

Microbiological and organoleptic testing simulated temperature abuse, elevated domestic refrigeration assumptions, and a home freeze/open-pack condition.

Results

The validation achieved the full target retail pack shelf life (P+20 days)

The validation demonstrated acceptable microbiological performance on all parameters tested for the material produced, see Table 1 in the appendix below.

There were no recorded raw or cooked adverse results. The validation organoleptic results note good raw visual and aroma, no excess blood in packs, and no off aromas or sensory issues in cooked joint assessments.

Complaints data is comparable for retail packed beef rump joints produced using this primal freezing process compared to beef rump joints produced from beef rump primals cut into retail rump joints at P+21 without primal freezing.

Summary

This validation demonstrates that freezing beef rump primal at P+20 days after an extended maturation in vacuum pack produces a safe, good quality chilled retail product.

Appendix

Table 1: Results from microbiological testing of joints produced using frozen primal material. A Salmonella limit of absence (cannot be present/detected), an E.coli O157 limit of absence (cannot be present/detected) and an E.coli limit of 500cfu/g is in place for the purposes of the current validation. Where elevations are noted, these are assessed holistically in respect of the full picture of the validation itself and whether they represent the full picture of the study.

TEST REPORT

Receipt Date: 29/04/2025 **Visual Inspection:** Satisfactory **Report ID:** N-418929
Order Number: 290425/PO9120580(SHELF LIFE TRIALS) **Report Issued:** 02/06/2025 07:28:16

Lab Reference	Test Date	Sample Descriptio	M011 Beta Glucuronidase Positive E.coli cfu/g	M041 Detection of Salmonella spp by Elisa in 25g	M059 Detection of Ecoli O157:H7 DNA in 25g
NS3952646	29/04/2025	PD250425/P+4 Toprump Joint Maturation pre freezing SL087-25 P+4	< 10		
NS3955923	10/05/2025	PD250425/P+15 Toprump Joint Maturation pre freezing Maturation pre freezing SL087-25 P+15	< 10	Not Detected	Not Detected

Table 2: Organoleptic panel results for Beef Joints. Overall, flavour was considered 'acceptable' at EOL. These scores and comments were considered to be within expected parameters for EOL. 1 = Unacceptable, 2 = Poor, 3 = Acceptable, 4 = Good, 5 = Excellent. Any N/A refers to a date where the parameter was not captured due to not being required following the validation process (cooked performance will not be assessed every day).

Day	Raw appearance	Raw aroma	Cooked appearance	Cooked aroma	Tenderness	Succulence	Flavour
P+1	4	N/A	N/A	N/A	N/A	N/A	N/A
P+2	4	N/A	N/A	N/A	N/A	N/A	N/A
P+3	4	N/A	N/A	N/A	N/A	N/A	N/A
P+4	4	5	5	5	5	5	5
P+5	4	N/A	N/A	N/A	N/A	N/A	N/A
P+6	4	N/A	N/A	N/A	N/A	N/A	N/A
P+7	4	N/A	N/A	N/A	N/A	N/A	N/A
P+8	4	N/A	N/A	N/A	N/A	N/A	N/A
P+9	4	N/A	N/A	N/A	N/A	N/A	N/A
P+10	4	N/A	N/A	N/A	N/A	N/A	N/A
P+11	4	N/A	N/A	N/A	N/A	N/A	N/A
P+12	4	N/A	N/A	N/A	N/A	N/A	N/A

Appendix 6

P+13	4	N/A	N/A	N/A	N/A	N/A	N/A
P+14	4	N/A	N/A	N/A	N/A	N/A	N/A
P+15	4	N/A	N/A	N/A	N/A	N/A	N/A
P+16	4	N/A	N/A	N/A	N/A	N/A	N/A
P+17	4	N/A	N/A	N/A	N/A	N/A	N/A
P+18	4	N/A	N/A	N/A	N/A	N/A	N/A
P+19	4	N/A	N/A	N/A	N/A	N/A	N/A
P+20	4	5	5	5	5	5	5
P+21	4	N/A	N/A	N/A	N/A	N/A	N/A
P+22	4	N/A	N/A	N/A	N/A	N/A	N/A
P+23	4	N/A	N/A	N/A	N/A	N/A	N/A
P+24	4	N/A	N/A	N/A	N/A	N/A	N/A

Appendix 7

Validation of Fresh Vacuum-Packed Lamb Rump (Including Customer Freezing)

Scope

The scope of this validation is the use of vacuum packaging for fresh lamb rump steaks, with consideration of customer freezing and domestic handling. Lamb rump steaks packed in skin packed trays were evaluated to support extension of fresh shelf life to pack plus 19 days (P+19).

Method

The validation utilised a structured, multi-line evidence approach combining microbiological testing and quality assessment.

35 finished product samples of lamb rump steaks packed in skin pack were produced to use in this testing and assessment.

The FSA guidance on "The safety and shelf-life of vacuum and modified atmosphere packed chilled foods with respect to non-proteolytic *Clostridium botulinum*" at the-safety-and-shelf-life-of-vacuum-and-modified-atmosphere-packed-chilled-foods-with-respect-to-non-proteolytic-clostridium-botulinum_1.pdf advises that intact red meat falls outside the scope of this guidance, that this guidance does not apply.

FSA guidance on domestic refrigeration temperatures recommends a fridge temperature of 5°C. It is noted that the average temperature for a UK domestic fridge is 4-7°C. The predictions below have been modelled on domestic refrigeration of 8°C or above as worst-case scenarios.

Finished packs of were subjected to depot temperatures (2-4°C), temperatures they would be exposed to within a retail setting in fridges (5°C), temperature abuse the consumer would subject the product to (22°C), and finally domestic storage by the consumer (8°C) until end of life (EOL).

Microbiological testing for Total Viable Count (TVC) and *E. coli* was undertaken through life to P+21 days, incorporating simulated temperature abuse, elevated domestic refrigeration assumptions, and a home freeze/open-pack condition.

Organoleptic evaluation was conducted internally at defined end-of-life timepoints (P+19, P+20 and P+21), assessing raw and cooked sensory characteristics against site-approved scoring criteria.

Results

Microbiological results demonstrated expected increases in TVC over time but remained within stated acceptance limits through the assessed life.
E. coli results were consistently low, remaining well below limits.

Appendix 7

See Table 1 in Appendix below.

Organoleptic assessment showed that all products remained acceptable at end of life. Minor flavour intensification was noted in rump steaks at P+21, but product maintained good sensory performance across all attributes.
See Table 2 in Appendix below

From a consumer perspective, complaint levels of fresh vacuum skin packed beef and lamb products, with extended life of up to P+19 days, has been supported by data over the past decade, and has shown to not significantly impact consumer sensory experience, or health. There is no evidence at present to suggest extended life has any negative impact on the UK consumer from a quality or safety perspective when validated using a HACCP based approach.

Summary

The microbiological and organoleptic results supports the use of vacuum packaging for fresh lamb products to P+19 days.

The validation confirms that the inclusion of customer freezing and domestic handling does not introduce unacceptable food safety or quality risks when products are managed in line with defined storage instructions.

Appendix 7

Appendix

Table 1: Results from microbiological testing of lamb rump steaks.
A TVC limit of 1,000,000 and an E.coli limit of 500 cfu/g is in place for the purposes of the current validation.
Where elevations are noted, these are assessed holistically in respect of the full picture of the validation itself and whether they represent the full picture of the study.

SAMPLE NUMBER		SAMPLE IDENTIFICATION									RESULTS		
Sample Number	Field ID	Start Date	Production Date	Category	Other ID	Log Date	Description	Shelf Num	SL Storage Temp	SL Test Day	Test: TP4145	TP4133	n/a*
											Det: spTVCF53	EcF	MoveTemp
											Unit: cfu / g	cfu / g	.
											Analysis Specification: Total Aerobic Colony count at 30°C	Beta glucuronidase Pos E.coli	Sample storage conditions changed
15680792		19/09/2024	18/09/2024	Shelf Life	SHELFLIFE DAY 1	19/09/2024	LAMB RUMP STEAKS	34678	2-4C	D1	<20000	<10	.
15683375		20/09/2024	18/09/2024	Shelf Life	SHELFLIFE DAY 2	20/09/2024	LAMB RUMP STEAKS	34678	2-4C2HR22CMV8C	D2	<20000	<10	.
15698192		28/09/2024	18/09/2024	Shelf Life	SHELFLIFE DAY 10	27/09/2024	LAMB RUMP STEAKS	34678	8C	D10	>40000000(	<10	.
15719244		06/10/2024	18/09/2024	Shelf Life	SHELFLIFE DAY 18	05/10/2024	LAMB RUMP STEAKS	34678	8C	D18	3800000	<10	.
15719335	#	06/10/2024	18/09/2024	Shelf Life	SHELFLIFE DAY 18	05/10/2024	DEFROST LAMB RUMP STEAKS	34680	8CMV-18C	D18	.	.	y
15720565		08/10/2024	18/09/2024	Shelf Life	SHELFLIFE DAY 20	07/10/2024	LAMB RUMP STEAKS	34678	8C	D20	13000000	<10	.
15729518		11/10/2024	18/09/2024	Shelf Life	SHELFLIFE DAY 23	10/10/2024	LAMB RUMP STEAKS	34678	8C LAST TEST	D23	21000000	<10	.
15729519		11/10/2024	18/09/2024	Shelf Life	SHELFLIFE DAY 23	10/10/2024	OPEN LAMB RUMP STEAKS	34679	8C LAST TEST	D23	1100000	<10	.
15754328		21/10/2024	18/09/2024	Shelf Life	SHELFLIFE DAY 33	20/10/2024	DEFROST LAMB RUMP STEAKS	34680	-18CMV8C LAST TEST	D33	8800000	<10	.

Table 2: Organoleptic panel results for lamb rump steaks.
Overall, flavour was considered 'acceptable' at EOL.
These scores and comments were considered to be within expected parameters for EOL.

- 1-2 = Unacceptable,
- 3-4 = Poor,
- 5-6 = Average,
- 7-8 = Good,
- 9-10 = Excellent.

Day	Raw appearance	Cooked appearance	Cooked aroma	Tenderness	Succulence	Flavour
P+19	8	7.2	7	7	7.2	5.6
Open pack	7	8	6.3	7	8	5.3
P+20	8	7.7	6.7	7	6.7	5.7
P+21	8	8	7.5	6.8	6.3	6.3