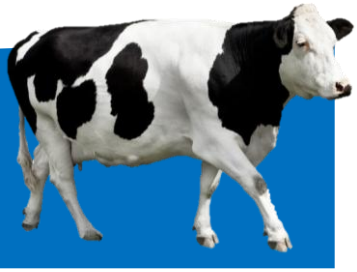
SERVICE LEAFLET

INTERCOOL FOOD TECHNOLOGY LTD.

Tailored Design of Beef Carcass Chilling Processes



Efficient beef carcass chilling is a cornerstone of modern meat processing – directly influencing product quality, shelf life, and profitability. From the moment a carcass enters the chilling environment, a carefully controlled process begins that determines not only measurable outcomes like weight loss, but also key quality attributes valued by both retailers and consumers.

Optimizing the chilling process is essential for achieving low chill loss, preserving tenderness, ensuring microbiological safety, and maintaining the bright, appealing color that signals freshness. Each of these factors plays a critical role in maximizing yield, safeguarding product integrity, and securing the highest possible market value.

However, delivering consistent results is not straightforward. Every carcass is unique, varying in weight, age, sex, muscularity, and fat cover. These differences influence how heat is removed and moisture is retained, making it challenging to apply a one-size-fits-all approach.

Designing an effective industrial chilling solution therefore requires a balance between throughput and precision – capable of handling large volumes while adapting to biological variability. The right chilling strategy ensures that every carcass, regardless of its characteristics, is processed under optimal conditions to meet both economic and quality objectives.

pH Value

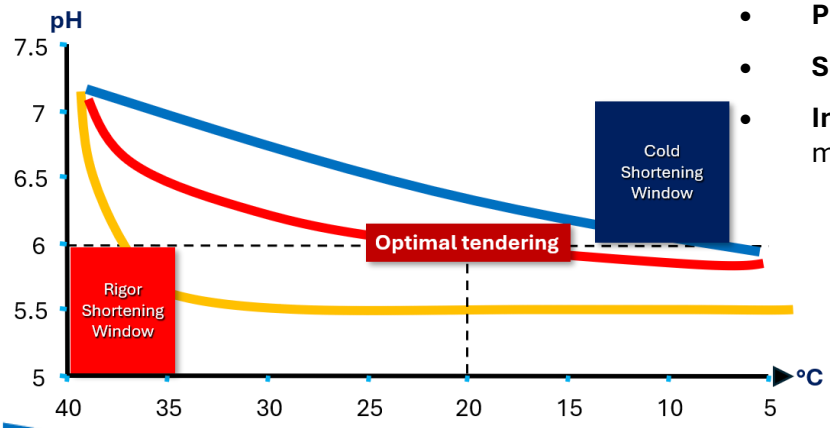
Controlling the pH during pre-slaughter, slaughter and chilling is 'one' of the cornerstones to your success.

pH is a measure of acidity, expressed on a scale ranging from 0 to 14, where pH 7.0 is defined as neutral. In abattoir operations, pH is used as an indicator of meat acidity, and it is a critical factor influencing meat quality and eating characteristics.

In living animals, muscle tissue typically has a pH value of approximately 7.5. After slaughter and subsequent chilling, the recommended pH range for the carcass is 5.5 to 5.9.

Following slaughter, residual energy in the form of glycogen remains in the muscles. As a result, muscle fibers continue to contract and relax, like their behaviour in live animals. During this postmortem metabolism, glycogen is converted into lactic acid, leading to a decline in muscle pH. Eventually, all available energy is depleted, causing the muscles to remain in a contracted state. This stage is known as Rigor Mortis.

In cattle, rigor mortis typically occurs within approximately 20 to 48 hours postmortem, depending on factors such as the animal's age and pre-slaughter handling conditions. The pH gradually stabilizes during the period between slaughter and the onset of rigor mortis. A proper decline in pH during this interval is essential for ensuring optimal meat quality.



CONSEQUENCES OF DEVIATIONS IN pH

High pH

Meat with a high pH (above pH 6.0) is referred to as **DFD meat (Dark, Firm, and Dry)** and is commonly observed in animals subjected to prolonged stress prior to slaughter. The elevated pH results from depletion of glycogen reserves in the muscle due to increased energy expenditure before slaughter. Consequently, less glycogen is available for post-mortem conversion into lactic acid.

The higher pH level leads to the following characteristics:

- **Firm and dry texture**, due to increased water-holding capacity within the muscle
- **Undesirable taste**, often described as dull or bland
- **Off-odor**, typically metallic or chemical in nature
- **Darker color** compared to normal meat
- **Reduced shelf life**, as the higher pH allows greater microbial survival and growth compared to meat with lower pH.

Low pH

Meat with a low pH is known as **PSE meat (Pale, Soft, and Exudative)** and may occur when animals experience acute stress immediately before slaughter. Stress can trigger the rapid release of glycogen into the muscles, leading to excessive lactic acid production during post-mortem glycolysis. This results in a rapid and excessive decline in pH.

A low pH value (around pH 5.0) can negatively affect eating quality by causing:

- **Pale or light-coloured meat**
- **Soft texture**
- **Increased drip loss** (loss of meat juices) in raw meat prior to cooking

CARCASS HEAT EXTRACTION

Depending on slaughter capacity, market requirements, and available investment, the physical and logistical process may be organized into different stages. However, heat removal typically occurs in two main phases:

- **Phase 1:** From slaughter to rigor mortis (24 to 48 hours)
- **Phase 2:** Subsequent ageing

The chilling regime and temperature profile have a significant impact on final meat tenderness:

- **Gentle chilling** of the carcass positively affects tenderness. For example, maintaining the meat at **10–15°C for 6 to 10 hours** during the rigor period improves outcomes. In practice, chilling is often too rapid when warm carcasses are placed in cold rooms alongside already chilled carcasses.

The Carcass

The older the animal, the longer the recommended stabilization period. Fat acts as an insulator, protecting muscles from rapid chilling. Therefore, muscles in carcasses with an appropriate fat cover cool more gradually than those in lean carcasses.

Chilling conditions must be adjusted according to carcass size and fatness. Achieving optimal chilling is easier when animals are uniform in type and condition.

AGEING

Meat is tough during rigor mortis due to the contraction of muscle fibers and the presence of connective tissue. After rigor mortis, the ageing process begins.

During ageing:

- Structural proteins in muscle fibers (**myofibrillar proteins**) are gradually broken down.
- This enzymatic degradation improves tenderness by making the meat easier to chew.

Ageing does **not** affect the toughness contributed by connective tissue, but it significantly reduces myofibrillar toughness.

The process is driven by naturally occurring enzymes within the muscle. A greater degree of protein breakdown and longer ageing periods generally result in improved tenderness.

Methods

Ageing is typically carried out at **2–5°C** and can be performed in two ways:

- **Vacuum ageing:** Meat is stored in vacuum packaging
- **Dry ageing (hanger ageing):** Carcasses or cuts are hung in a chilled environment

An alternative hanging method is suspension from the **pelvic bone (hip suspension)** rather than the Achilles tendon. If performed within the first 48 hours post-slaughter, this method improves tenderness because certain muscles (especially in the loin and hindquarter) contract less compared to conventional suspension.

Dry ageing does not necessarily increase tenderness compared to vacuum ageing, but it contributes significantly to **flavour development**. However, it leads to higher yield losses due to evaporation and trimming.

Achilles Hung **Hip Hung**

Conventional achilleas hung and tender-stretch-hung body right.

AGEING TIME

The tougher the meat initially, the longer the required ageing period. Ageing progresses most rapidly at the beginning but can, in principle, continue for **more than 100 days**.

FACTORS AFFECTING AGEING

Age

Older animals require longer ageing periods to achieve optimal tenderness.

Growth Rate

Animals with low growth rates – such as those raised extensively on natural pastures – often exhibit different muscle protein turnover. These animals generally require longer ageing compared to intensively fed animals with higher growth rates.

Stress Level

Stress at slaughter can result in **DFD meat (Dark, Firm, Dry)**, which is typically tougher.

FAT

Fat Distribution

Fat within meat is categorized as:

- **Intramuscular fat (marbling):** Located within the muscle
- **Intermuscular fat:** Located between muscles

Intramuscular fat improves tenderness by effectively diluting the muscle fiber structure. Both intra- and intermuscular fat contribute to flavour after cooking.

Intramuscular fat also influences post-slaughter chilling, while the external fat layer (**subcutaneous fat**) affects insulation and cooling rate.

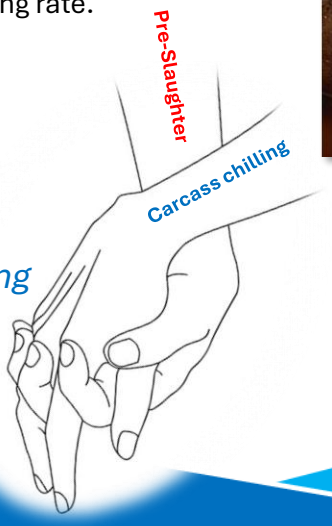
Fat Content

Animals slaughtered directly from pasture typically have relatively low-fat levels.

- **Steers and heifers** generally have higher fat content than bulls
- Older animals typically have more fat than younger ones

Carcass fatness directly affects classification and pricing. Lean carcasses are more difficult to chill optimally and are more prone to drying during chilling.

Fat plays a **crucial role in eating quality**, particularly in terms of flavour.



Pre-Slaughter & Chilling goes hand in hand!

INTERCOOL FOOD TECHNOLOGY LTD.

- offers offer our expertise and assistance in designing engineering your future process

CHILLING PROCESS DESIGN

- Optimized to your meat quality demands
- Low chill loss
- Low drip/packing loss
- Tenderness
- High safety and longer shelf life

COOLING EQUIPMENT SPECIFICATION

- Cooling capacity
- Evaporator design and dimensioning
- Evaporator placement
- Defrosting sequence

CONVEYOR SPECIFICATION

- Internal logistic solution
- Conveyor length, pitch, layout

BUILDING DETAIL DRAWING AND DESCRIPTIONS

- Floor, column, wall, and roof construction
- Drains, pressure reliefs, air locks

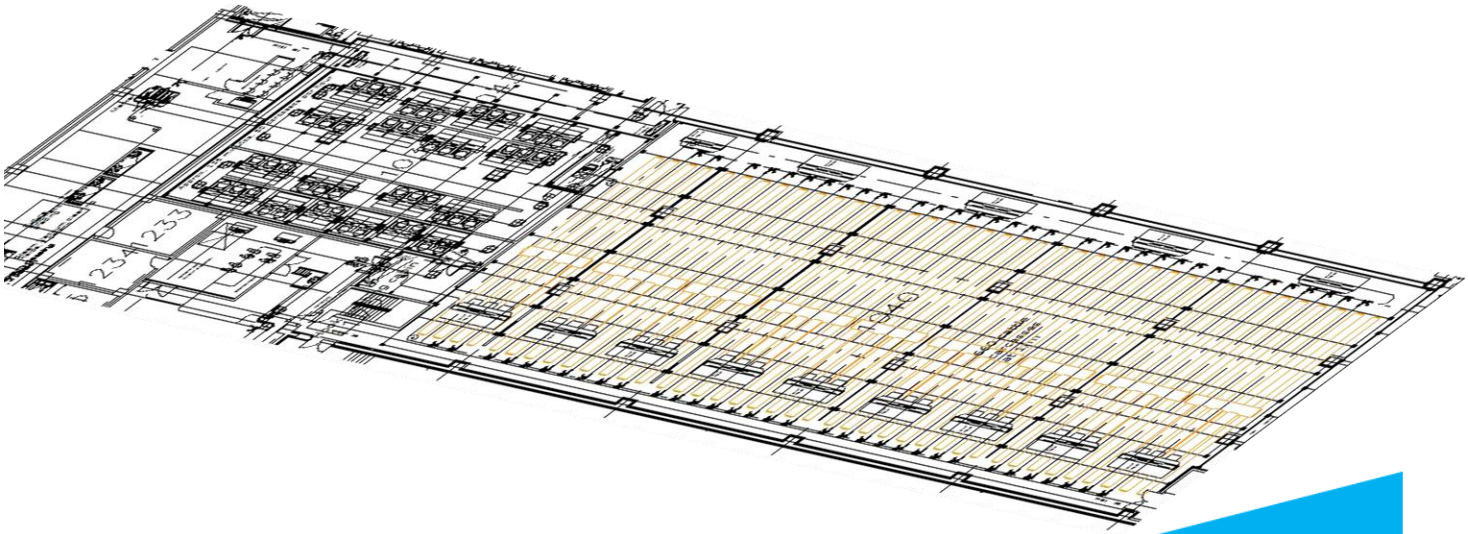
SECONDARY STEEL DESIGN

- Avoid conflicts with building and equipment
- Placement of columns and beams according to evaporators and conveyors.

As a result of the research performed by DMRI over the years, we possess unique knowledge about the thermal processes of meat, fat, rind, and bone. This knowledge is compiled in our proprietary software, which enables us to simulate carcass chilling processes and accurately predict the resulting chill loss. This software is the backbone in our work when we design a carcass chilling process, adapted to your specific needs.

Basis for the design is the slaughter capacity and characteristics of the carcasses; hot carcass weight, lean meat percentage, and back fat thickness. The process is then optimized to optimally fit your market demands.

STRICT INTERFACE & COORDINATION BETWEEN



Typical Methodology & Work Plan in Building Projects

1. **Concept Development Plan**
2. **Master Plan**
3. **Concept Design**
4. **Tender Design & Document**
5. **Procurement**
6. **Construction**
7. **Start-up & Commissioning**

Based on your products and markets, we take a holistic approach to avoid counterproductive sub-optimization.

Stage 1: Concept Development

This phase includes estimated CAPEX and an analysis of the impact on OPEX, ensuring the project's profitability from the outset.

Stage 2: Master Plan

We complete the full project description, including layouts, logistics and planning documentation.

Stage 3: Concept Design

This stage provides all the necessary detailed information to obtain comparable bids from qualified suppliers.

If desired, we can support the project through every phase, including start-up and commissioning.

When we are involved throughout the entire project and it is executed according to our specifications, we can offer a **Chill Loss Guarantee.**

INTERCOOL FOOD TECHNOLOGY LTD.
Your solution facilitator

Niels Conradsen
Senior Project Manager
C +45 2815 0615
M nco@intercool.dk