Evaluating Shell-Superchilling and Extended Wet-Aging for Retail Beef

Abstract

This study investigates the effect of Shell-Superchilling Treatment on M. semitendinosus (Eye of Round) beef steaks to assess the aging quality of a 42-day wet-aging process using King Son Constancy IFP Chilling Technology. The treatment is conducted at -2.2°C within the King Son Convertible IFP Aging Chiller, under precisely controlled conditions.

The goal is to validate the commercial viability, aging performance, and retail value enhancement of extended wet-aged lean beef cuts for targeted retail market sales.

Background and Context

Beef palatability, encompassing tenderness, flavor, and juiciness, is a primary driver of consumer satisfaction and market value. Premium cuts like tenderloin and ribeye are highly sought after, but economic pressures, such as rising feed costs and environmental challenges, have increased the need to enhance lower-value cuts like the M. semitendinosus (Eye of Round). This cut, known for its toughness, is often under-aged (less than 14 days) at retail, limiting its commercial potential.

Wet-aging, the process of vacuum-sealing and refrigerating beef, is the most common aging method in the meat industry, typically lasting 7–21 days. Extending aging beyond 35 days risks off-flavors (e.g., metallic, sour), but advanced chilling technologies, such as King Son Constancy Initial Freezing Point (IFP) Chilling, offer a solution by maintaining quality at temperatures just above the freezing point. This study investigates whether Shell-Superchilling, combined with IFP Chilling at -2.2°C, can improve the palatability of Eye of Round steaks over a 42-day wet-aging period, aligning with the user’s specified focus.

Methodology

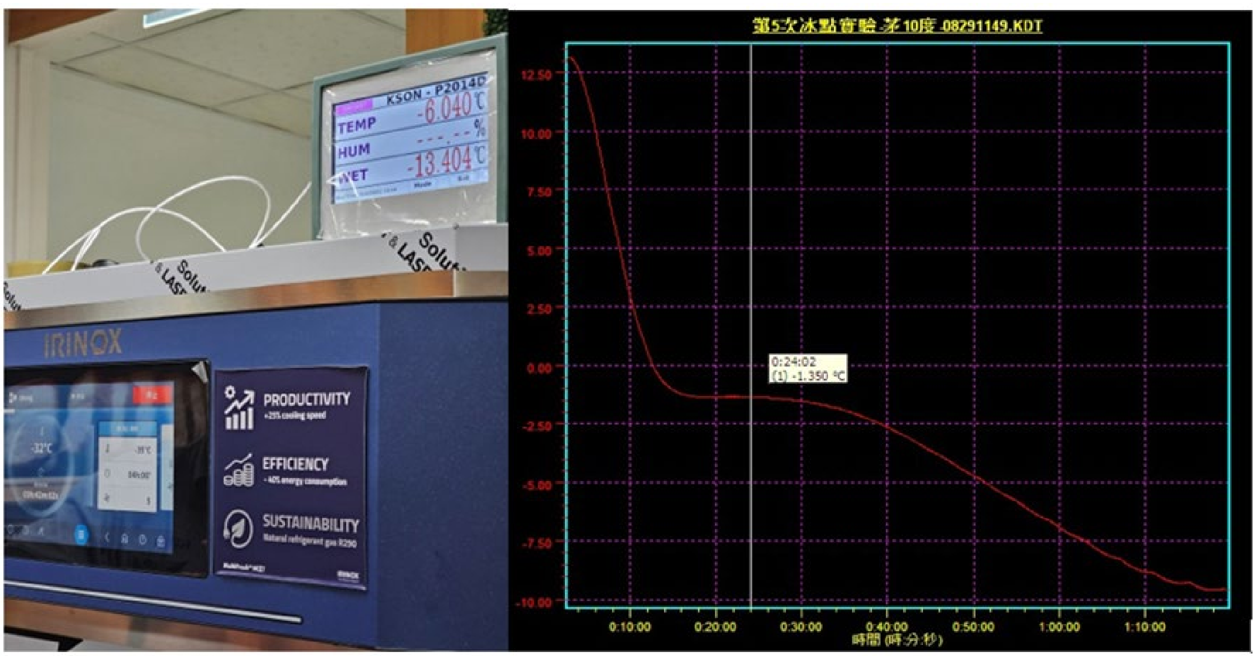
The study employed a rigorous experimental design to assess the effects of Shell-Superchilling and extended wet-aging on M. semitendinosus steaks.

Muscle Selection and Preparation

- **Source**: A 1.74 kg M. semitendinosus muscle from Taiwan Angus beef was sourced from Farm Around You pasture (Farm Around You), slaughtered on August 27, 2024, and delivered vacuum-packed on August 29, 2024.
- **Initial Processing**: The muscle was trimmed, tested for pH (5.28), sweetness (16.0%), and shear force (759.7 g), and rested at -1.9°C for three days in a King Son Convertible IFP Aging Chiller. The initial freezing point was -1.3°C.
- **Steak Fabrication**: The muscle was cut into six steaks (1.5–2 cm thick) for treatment and aging.

Shell-Superchilling Treatment

- **Equipment**: IRINOX Blast Chiller.
- **Process**: Steaks were subjected to Shell-Superchilling at -35°C for 5 minutes, achieving less than 30% surface ice content. This method partially freezes the surface to preserve quality without damaging cell structure, maintaining sensory and nutritional attributes.



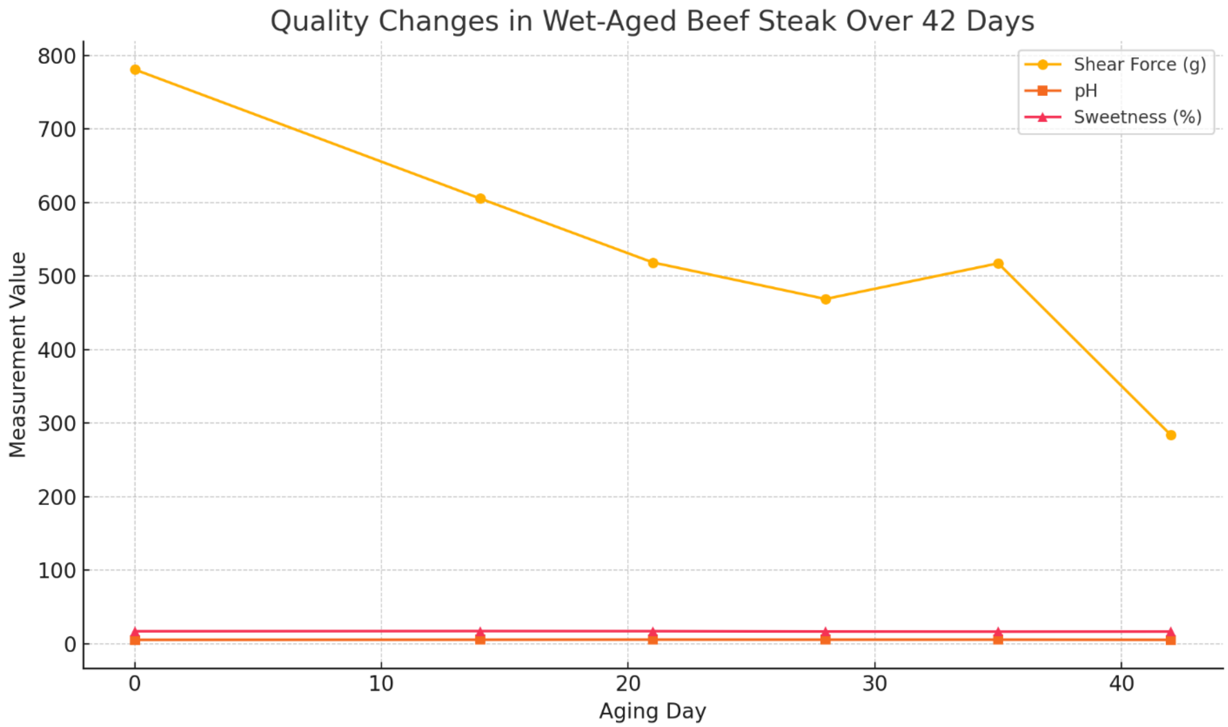
Storage and Aging

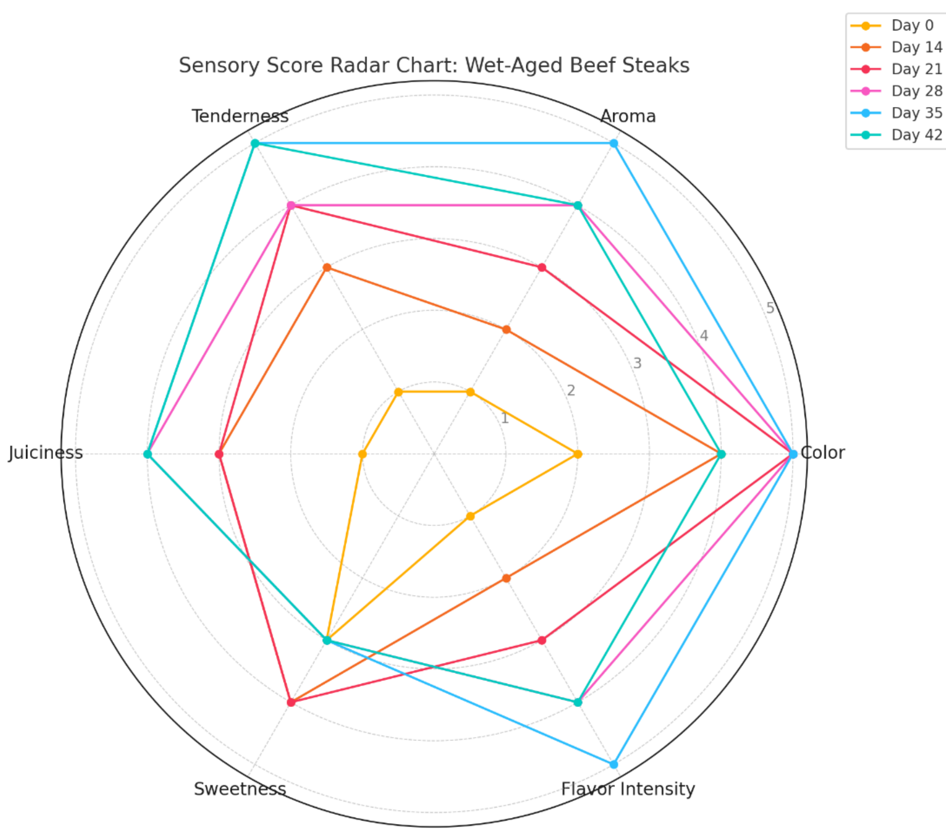
- **Aging Technology**:
    - King Son Constancy IFP Chilling Technology operates precisely at 0°C (32°F)—a temperature just above the initial freezing point of food—enabling safe, enzyme-active wet-aging without freezing damage, drip loss, or spoilage.
    - In advanced applications, the King Son Convertible IFP Aging Chiller utilizes this technology at -2.2°C, with ±0.3°C temperature precision and ±5% humidity control, enhanced by AIoT-based real-time monitoring for continuous optimization of aging conditions.
- **Aging Period**: Steaks were vacuum-packed and aged for 0, 14, 21, 28, 35, and 42 days, with quality assessments at each interval.
- **Measurements**: Parameters included pH, sweetness, shear force (tenderness), and sensory attributes (color, aroma, texture, flavor, juiciness). Steaks were cooked via pan-frying (medium-well) or sous vide (55–58°C for 1.5 hours) for evaluation.

Results

The study tracked changes in steak quality over 42 days, with detailed measurements and sensory evaluations:

Day	Shear Force (g)	pH	Sweetness (%)	Sensory Observations
0	781	5.12	16.9	The beef steak exhibited a dark coloration with no discernible beefy aroma. Upon pan-frying, it maintained a firm and tough texture, making it well-suited as a baseline reference for evaluating the effects of aging on sensory and textural improvements.
14	605.5	5.26	17.1	The beef steak exhibited a lighter red hue, accompanied by improved tenderness and juiciness. A subtle sweetness was present, positioning it as a suitable option for mid-tier market segments that value balanced flavor and texture.
21	453.0 – 584.1	5.39	17.0	The beef steak exhibited a dark red color with a subtle aging aroma. While tenderness had noticeably improved, the flavor profile remained underdeveloped, indicating that an additional week of aging is necessary to achieve optimal flavor balance.
28	427.1 – 510.6	5.32	16.6	The beef steak exhibited a dark red color, with a distinct Yakult-like lactic aroma and cheesy aged notes. It reached consumer-acceptable tenderness and juiciness, positioning it as a suitable option for premium retail and high-end foodservice markets.
35	290.5 – 744.2	5.34	16.4	The beef steak exhibited a deep, dark red coloration, accompanied by rich and mature aromatic notes reminiscent of aged cheese and red wine. It demonstrated superior tenderness and a robust, full-bodied flavor, offering a taste profile comparable to premium-grade sirloin.
42	256.3 – 311.1	5.13	16.5	The beef steak showed a color transition from dark red to brownish hues, demonstrating excellent tenderness and a subtle tangy aftertaste. Although the aging flavor remained well-balanced and enjoyable, its overall intensity was marginally diminished compared to the peak flavor profile observed on Day 35.


Quality Changes in Wet-Aged Beef Steak Over 42 Days
Shear Force (g)
pH
Sweetness (%)
Measurement Value
Aging Day
0
100
200
300
400
500
600
700
800
0
10
20
30
40


Sensory Score Radar Chart: Wet-Aged Beef Steaks
Day 0
Day 14
Day 21
Day 28
Day 35
Day 42
Tenderness
Aroma
Color
Flavor Intensity
Sweetness
Juiciness
1
2
3
4
5

Discussion

The Shell-Superchilling treatment and IFP Chilling at -2.2°C significantly enhanced the palatability of M. semitendinosus steaks. Tenderness improved progressively, with shear force decreasing from 781 g (Day 0) to 256.3–311.1 g (Day 42). Flavor and juiciness peaked at 35 days, with rich, desirable aromas and no off-flavors, unlike traditional aging methods where off-flavors may emerge beyond 35 days. By Day 42, while tenderness remained excellent, flavor intensity slightly declined, though the steaks remained suitable for premium markets.

The King Son Constancy IFP Chilling Technology maintained quality by operating just above the initial freezing point (-1.3°C), minimizing tissue damage and microbial growth. This approach outperformed traditional freezing, which often results in drip loss and reduced juiciness. The use of AIoT monitoring ensured consistent conditions, supporting the commercial viability of extended aging for retail sales.

Conclusions

The study demonstrates that Shell-Superchilling combined with 35-day wet-aging at -2.2°C using King Son Constancy IFP Chilling Technology significantly enhances the tenderness, juiciness, and flavor of M. semitendinosus steaks, making them comparable to high-end cuts. While 42-day aging maintains excellent tenderness and juiciness, flavor peaks at 35 days, suggesting this as the optimal aging period for premium retail and restaurant markets. This method offers a promising strategy to increase the economic value of tough beef cuts, meeting consumer demand for tender, flavorful beef.

Key Citations

- Farm Around You Pasture Website