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Abstract

While the impact of freezing beef is well studied among published literature, thawing has not received the same level of attention. The objective of the current study was to evaluate six thawing methods for palatability: the four USDA approved thawing methods (thawing in a refrigerator, cold water, microwave, and cooking from a frozen state), as well as two methods commonly used by consumers (thawing in hot water and on the counter). Paired Low Choice strip loins ($n = 15$) were collected from a beef packing facility. The paired loins were fabricated into 1-in steaks and blocked into six blocks of four steaks. Each block was assigned a different thawing method, and each steak within the block a test. The samples were then aged 21 days and frozen. Fifteen trained panels were performed, with 8 panelists consuming 6 samples from the same loin. Each steak was cooked to a peak temperature of 160°F on clamshell style grills. Data were analyzed as a completely randomized block design. Steaks thawed in a microwave and cooked from frozen were less tender ($P < 0.05$) than steaks thawed in cold water or in a refrigerator, while steaks cooked from frozen were rated higher ($P < 0.05$) for beef flavor intensity than all other methods. Moreover, steaks thawed in a microwave had lower ($P < 0.05$) a^* (redness) and b^* (yellowness) values than steaks thawed in a refrigerator, cold water, and hot water. Steaks thawed in a microwave had a higher ($P < 0.05$) thaw loss, cook loss, and total moisture loss than steaks thawed in a refrigerator, cold water, and on the counter. The thawing method utilized has a minimal impact on palatability. However, increases in moisture loss can have a negative economic impact. Therefore, consumers should utilize whichever thaw method they prefer, keeping food safety as the highest priority.

Introduction

Freezing, and thus the thawing process, has been utilized for meat preservation for decades. The importance and prevalence for freezing has only increased as demand for meat export to Asian countries continues to rise (Ren et al., 2022; USDA, 2023). Moreover, the effects of freezing on meat quality has been widely investigated. There is evidence that ice crystal formation causes damage to muscle fibers, which causes an increase in tenderness and reduction of juiciness ratings of frozen samples (Rahelić

et al., 1985; Kim et al., 2015; Beyer, 2023). However, published literature exploring the effect of thawing method on beef quality is more limited. There are studies that look at one or two thawing methods compared to thawing in a refrigerator, and even still, few of those studies have a trained or consumer sensory panel component, or a complete array of instrumental quality measures. Moreover, the USDA has established four thawing methods defined as safe: thawing in a refrigerator, cold water, microwave, and cooking from a frozen state. Still, consumers commonly utilize other methods to thaw meat, such as thawing on a counter and in hot water (Benli, 2015). Therefore, the purpose of the current study was to evaluate six common thawing methods and to assess quality attributes using a trained panelist evaluation and a wide array of instrumental quality measures.

Experimental Procedures

Paired Low Choice strip loins ($n = 15$) were collected from a midwestern packing facility and transported to the Kansas State University Meat Laboratory. On day 11 of aging, loins were fabricated into 1-in thick steaks. Each pair of loins was sectioned into six equal blocks, and those blocks assigned to one of six thaw methods. Each steak was assigned a 4-digit ID, a test, then vacuum packaged and aged an additional 10 days prior to freezing (-4°F), for a total of 21 days of aging. Thaw methods consisted of the four USDA-approved thaw methods: refrigerator (REF), cold water (CW), microwave (MIC), cooking from frozen (COOK), and two methods commonly used by consumers: countertop (CT) and hot water (HW). Steaks assigned to REF were thawed in a refrigerator at $34\text{--}37^{\circ}\text{F}$ for 24 hours prior to cooking. Steaks assigned to CW were thawed in individual containers of $34\text{--}37^{\circ}\text{F}$ water for 24 hours prior to cooking. COOK steaks were cooked immediately upon removal from the freezer, while still in a frozen state. The CT steaks were thawed at ambient temperature (68°F) for 5 hours. The HW steaks were thawed in a sous vide machine set to 104°F for 20 minutes (± 2 minutes). The MIC steaks were microwaved at 50% power for 3.5 minutes, flipped, and repeated in a retail microwave. Steaks were cooked to a final peak temperature of 160°F on clamshell-style grills, with temperature being monitored throughout the cooking process. Fifteen sensory panels were performed by eight trained panelists, with each panelist evaluating one sample from each treatment from the same loin. The samples were rated on a 100-point line scale with anchors at 0 (extremely dry/tough/bland/none), 50 (neither dry nor juicy, tough nor tender), and 100 (extremely juicy/tender/abundant/intense). Moreover, analyses were performed for slice shear force (SSF), Warner-Bratzler shear force (WBSF), expressible moisture, internal instrumental cooked color, thaw loss, cook loss, and total moisture loss. Data were analyzed as a completely randomized block design.

Results and Discussion

As a whole, thawing method had a minimal impact on palatability. There were no ($P > 0.05$) differences among thawing methods for initial juiciness, sustained juiciness, connective tissue, pressed juice percentage, L^* (lightness), lipid oxidation, WBSF and SSF (Table 1). For myofibrillar tenderness, COOK steaks were tougher ($P < 0.05$) than REF and CW. Also, MIC and COOK steaks were lower ($P < 0.05$) than CW and REF steaks for overall tenderness, while all other treatments were similar ($P > 0.05$). COOK steaks were rated higher ($P < 0.05$) than all other treatments for beef flavor intensity. MIC steaks had lower ($P < 0.05$) cooked a^* (redness) and b^* (yellowness) values than REF, HW, and CW steaks, while CT samples had higher ($P < 0.05$) values

than COOK and MIC. MIC steaks had the highest ($P < 0.05$) cook loss, followed by COOK ($P < 0.05$), with all other treatments being similar (MIC > COOK > CT = HW = CW = REF). The MIC and HW had a higher ($P < 0.05$) thaw loss than CW, CT, and REF (MIC = HW > CW = CT = REF). Moreover, MIC, COOK, and HW steaks had a higher ($P < 0.05$) percent total moisture loss than REF, CW, and CT. This increase in total moisture loss and thaw loss could indicate a total economic loss of steaks thawed using these methods. Lastly, COOK steaks had higher ($P < 0.05$) cooked expressible moisture than CT, CW, and REF.

Implications

These results show that consumers and food service establishments may use whichever thawing method is the most economical and convenient for them, as it does not impact eating quality, although food safety should be the utmost concern.

Acknowledgments

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Table 1. Least square means for Warner-Bratzler shear force (WBSF), slice shear force, cooking characteristics, and instrumental cooked color of frozen beef strip loin steaks thawed using various thaw methods

	Countertop ¹	Cook from frozen ²	Cold water ³	Hot water ⁴	Microwave ⁵	Refrigerator ⁶	P-value	SEM ⁷
L*	56.7	55.0	56.0	55.3	55.5	55.9	0.16	0.6
a*	21.3 ^a	18.2 ^{bc}	20.4 ^{ab}	20.3 ^{ab}	16.4 ^c	20.5 ^{ab}	0.02	1.1
b*	19.2 ^a	17.7 ^{bc}	18.9 ^{ab}	18.7 ^{ab}	16.9 ^c	18.9 ^{ab}	< 0.01	0.5
Slice shear force, lb	32.0	34.4	33.1	32.4	34.2	32.6	0.78	0.7
WBSF, lb	7.9	7.9	7.7	7.5	8.4	8.2	0.15	0.1
Cook loss, % ⁸	15.0 ^c	18.1 ^b	14.6 ^c	14.4 ^c	19.4 ^a	15.4 ^c	< 0.01	0.5
Thaw loss, % ⁹	1.2 ^b	---	0.9 ^b	3.7 ^a	4.2 ^a	0.8 ^b	< 0.01	0.4
Total loss, % ¹⁰	16.1 ^b	18.3 ^a	15.4 ^b	18.1 ^a	19.4 ^a	16.0 ^b	< 0.01	0.8
PJP ¹¹	13.7	13.5	14.7	14.8	15.2	13.8	0.23	0.0
Moisture, %	69.3 ^{ab}	---	69.6 ^a	69.7 ^a	68.8 ^b	69.8 ^a	0.04	0.4
Fat, %	9.0 ^a	---	8.1 ^{ab}	8.1 ^{ab}	9.0 ^a	7.5 ^b	0.04	0.5
Malonaldehyde/kg ¹²	0.2	---	0.2	0.2	0.2	0.2	0.61	0.0
Expressible moisture, %	7.9 ^b	10.1 ^a	7.9 ^b	8.9 ^{ab}	8.8 ^{ab}	8.3 ^b	0.03	0.5
WHC, % ¹³	92.2 ^a	89.9 ^b	92.1 ^a	91.1 ^{ab}	91.2 ^{ab}	91.7 ^a	0.03	0.5

^{abc}Least squares means in the same row without a common superscript differ ($P < 0.05$).

¹Thawed at 63–68°F for approximately 5 hours, or until internal temperature reached 32°F.

²Cooked immediately upon removal from the freezer while still in a frozen state.

³Thawed in individual plastic containers of 36–37°F water for 24 hours.

⁴Thawed in 104°F water for 20 minutes (± 2 minutes) utilizing a sous vide machine to maintain water temperature.

⁵Microwaved in a retail microwave at 50% power for 180 seconds, rotated, and microwaved for an additional 180 seconds, microwaving for an additional 30–60 seconds if not completely thawed.

⁶Thawed at 36–37°F in open air in a refrigerator.

⁷Standard error of the mean (largest) of the least square means.

⁸Cook loss percentage = [(raw weight – cooked weight) / raw weight] \times 100.

⁹Thaw loss percentage = [(steak in package – raw steak weight – dried package weight) / raw steak weight] \times 100.

¹⁰Total loss = [(steak in package – dried package weight – cooked weight) / raw steak weight] \times 100.

¹¹Pressed juice percentage.

¹²mg of malonaldehyde/kg of meat.

¹³Water holding capacity.

Temperature by time prior to thawing

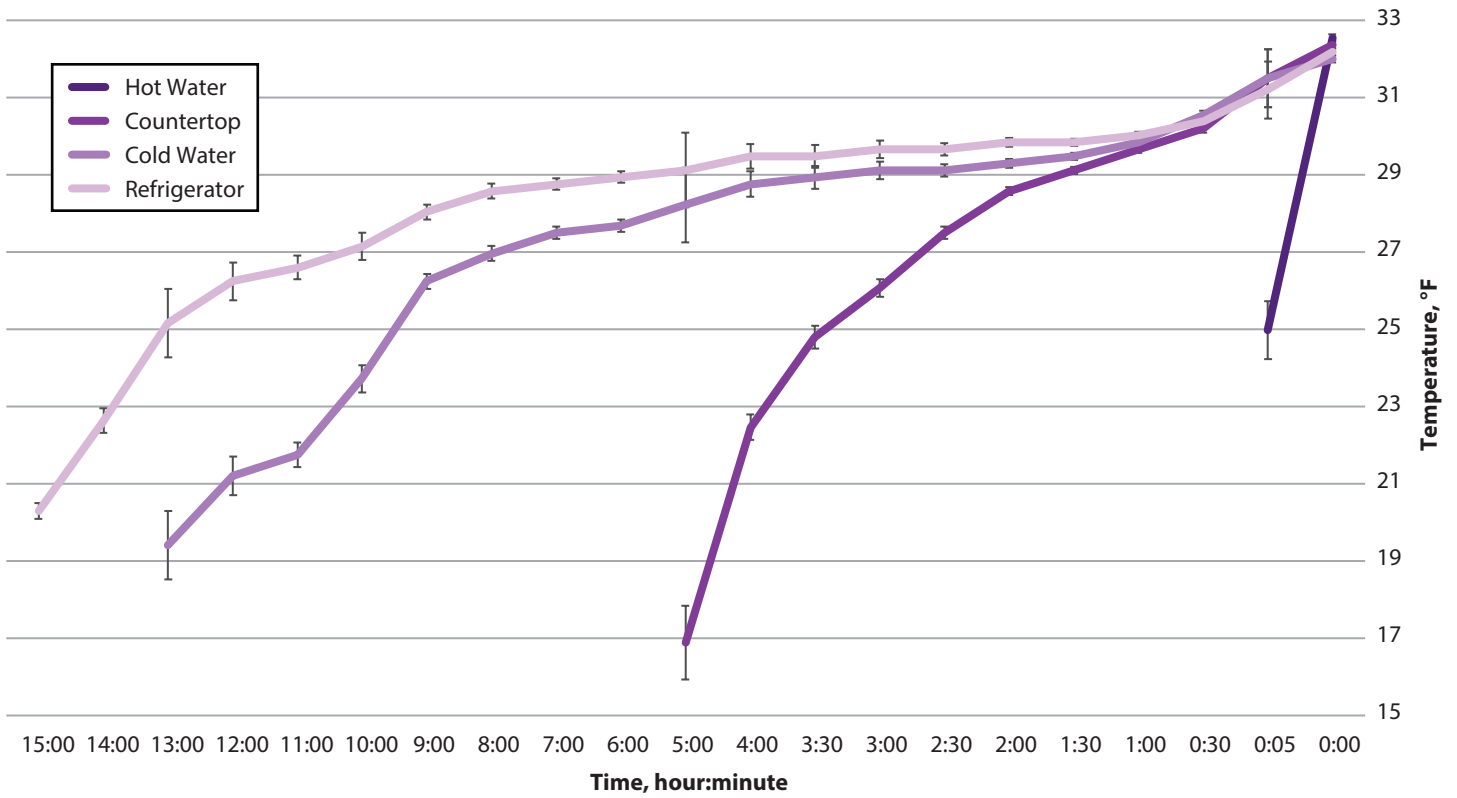


Figure 1. Temperature by time prior to thawing.