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Summary

Beef ribeye rolls, strip loins, and top sirloin butts were aged for 14 days and then blast or conventionally frozen and slow or fast thawed, or were fresh, never frozen and aged for 14 days or 21 days (n = 270). Thawing method affected purge loss and tenderness, and freezing method had a minimal effect. Neither freezing nor thawing methods had an effect on sensory tenderness, and minimal effects on the other sensory attributes. It is possible to freeze and thaw beef subprimals and for the meat to be comparable in tenderness and sensory attributes to fresh, never frozen meat.

Introduction

The 2006 National Beef Tenderness Survey showed the average length of aging for steaks in restaurant settings to be 30 days (Savell et al., 2006, *Journal of Animal Science* 33:111), with a range of 7 to 136 days; 29% of the steaks had less than 14 days of aging. This can lead to inconsistency between products. In the summer not all restaurants have the supply of steaks needed to meet the demand and are forced to use steaks with too little aging. A solution could possibly be to freeze and store subprimals after a specific degree of aging. The hypothesis of this project was that if subprimals are properly frozen and thawed, these subprimals would have the same quality of fresh subprimals with similar aging.

Procedure

At 14 days postmortem, 60 ribeye rolls (*Longissimus Thoracic*, LT), strip loins (*Longissimus Lumborum* LL), and top sirloin butts (*Gluteus Medius,* GM) were frozen at a warehouse in a -18°F freezer in Denver, Colo. Thirty LT, LL, and GM were blast frozen. The boxes were placed on pallets with spacers between pallets and high air velocity to allow for more rapid freezing. The other 30 LT, LL, and GM were conventionally frozen. The boxes were left packed tightly on the pallet with minimal air movement. All LT, LL, and GM were frozen for a minimum of 14 days. Frozen subprimals were numbered, weighed and then placed on a table at 32°F for 14 days to allow for slow thawing. Fast thawing occurred in a 54°F water bath with air agitation in 41°F room in the Loeffel Meat Laboratory for 21 hours prior to cutting. The water bath temperature dropped as soon as the subprimals were added. The final water bath temperature was between 32-39°F. The fresh, never frozen beef subprimals were aged in a 32°F cooler for 14 and 21 days prior to cutting. The six treatments were: blast frozen – slow thaw (BS), blast frozen – fast thaw (BF), conventionally frozen – slow thaw (CS), conventionally frozen – fast thaw (CF), fresh, never frozen 14-day aged (14D), and fresh, never frozen 21-day aged (21D).

Top Sirloin Butt (*gluteus medius*) subprimals were cut into 1-in steaks. The two steaks from the center of the GM were used for Warner-Bratzler shear force (WBS), cooking loss, and sensory evaluation. Two 1-in steaks were cut from the anterior portion of LL and the posterior end of LT for WBS, cooking loss, and sensory evaluation.

All WBS steaks were cooked on the day of cutting. Sensory evaluation steaks were vacuum-packaged and placed in a 39°F cooler until sensory evaluation. All steaks were cooked within three days of being cut.

Purge Loss

Purge loss was calculated on every subprimal. Frozen weights were recorded prior to thawing. Prior to cutting, all thawed and fresh, never frozen subprimals were weighed.

Warner-Bratzler Shear Force and cooking loss

Shear force values were determined on one steak from each subprimal. Steaks were grilled on Hamilton Beach Indoor/Outdoor grills. Steaks were cooked on one side until the center temperature reached 95°F and then turned over. Cooking continued until the temperature reached 160°F. Steaks were weighed before and after grilling. Cooking loss was calculated. Steaks were placed on a tray and covered with oxygen-permeable film and placed in a 39°F cooler. Twenty hours later, the cooked steaks were cored into 6 ½-in cores and sheared to determine WBS.

Sensory Panel

For sensory panel evaluation, steaks were prepared and cooked in the same manner described for Warner-Bratzler shear force. Upon reaching 160°F steaks were removed from the grill and cut into 1.27 cm^2 cubes and kept warm (not more than 15 minutes) prior to being evaluated. The steaks were served to 4-7 trained panelists while still warm.

(Continued on next page)

Table 1. Least square means of Warner-Bratzler shear force (WBS) and purge loss.

Muscle	Trait	Treatments[1]: 14 Day Aged	21 Day Aged	Blast Frozen, Fast Thaw	Blast Frozen, Slow Thaw	Conventional Frozen, Fast Thaw	Conventional Frozen, Slow Thaw	P-value[2]	Contrasts: Blast Frozen vs. Conventional Frozen	Slow Thaw vs. Fast Thaw
Longissimus Thoracic	WBS, kg	3.44^{c}	3.10^{c}	4.45^{a}	3.70^{bc}	4.21^{ab}	3.53^{c}	0.001	0.4825	0.2897
	Purge Loss, %	0.68^{b}	1.01^{b}	0.98^{b}	5.30^{a}	0.72^{b}	4.49^{a}	<0.0001	0.5431	<0.0001
Longissimus Lumborum	WBS, kg	3.55^{ab}	3.32^{abc}	3.55^{ab}	2.93^{bc}	3.94^{a}	2.83^{c}	0.01	0.5177	0.0004
	Purge Loss, %	1.78^{b}	1.88^{b}	0.88^{c}	3.53^{a}	0.78^{c}	3.53^{a}	<0.0001	0.8171	<0.0001
Gluteus Medius	WBS, kg	3.35	3.21	4.08	3.48	3.51	3.54	0.08	0.2411	0.1845
	Purge Loss, %	1.25^{bc}	1.56^{b}	0.79^{cd}	6.17^{a}	0.53^{d}	6.23^{a}	<0.0001	0.7060	<0.0001

a, b, c, dMeans in the same row having different superscripts are significant at $P \leq 0.05$.
[1]Blast Frozen = spacers placed between boxes of meat and placed in a -28°C freezer with high air velocity, Conventional Frozen = boxes of meat placed in a -28°C freezer with minimal air movement, Slow Thaw = subprimals set on a table in a 0°C room for 14 days, Fast Thaw = subprimals immersed in a circulating water bath (< 12°C) for 21 hrs 14 Day Aged = Aged for 14 days and fresh, never frozen, 21 Day Aged = Aged for 21 days and fresh, never frozen.
[2]*P*-value for the interaction between freezing process and thawing process.

Table 2. Least square means of sensory attributes.

Muscle	Trait	Treatments[1]: 14 Day Aged	21 Day Aged	Blast Frozen, Fast Thaw	Blast Frozen, Slow Thaw	Conventional Frozen, Fast Thaw	Conventional Frozen, Slow Thaw	P-value[2]	Contrasts: Blast Frozen vs. Conventional Frozen	Slow Thaw vs. Fast Thaw
Longissimus Thoracic	Tenderness	5.80	5.94	5.12	5.30	5.55	5.67	0.07	0.0613	0.4692
	Juiciness	5.08^{a}	5.07^{a}	4.12^{b}	4.34^{b}	4.48^{b}	4.30^{b}	0.001	0.4384	0.8965
	Connective Tissue	5.04	5.48	4.68	4.85	5.14	5.32	0.09	0.0268	0.3961
	Off-Flavor	2.10	2.14	1.88	1.97	2.05	2.02	0.30	0.1356	0.6648
	Cooking Loss	17.36^{b}	16.53^{b}	21.24^{a}	19.41^{ab}	22.31^{a}	20.51^{a}	0.001	0.3511	0.1230
Longissimus Lumborum	Tenderness	6.03	5.90	6.07	6.31	5.79	6.37	0.10	0.5327	0.0194\
	Juiciness	5.63	5.24	4.99	5.03	5.32	5.19	0.17	0.1977	0.8044
	Connective Tissue	5.61^{ab}	5.55^{b}	5.77^{ab}	6.04^{a}	5.37^{b}	6.02^{a}	0.02	0.1842	0.0032
	Off-Flavor	1.93	1.92	1.89	2.04	1.81	1.86	0.49	0.0751	0.1722
	Cooking Loss	20.95	16.51	17.21	19.33	19.36	17.67	0.41	0.8728	0.8882
Gluteus Medius	Tenderness	5.43	5.88	5.54	5.89	5.59	5.52	0.33	0.6811	0.8198
	Juiciness	5.01	5.36	5.33	4.70	5.04	4.55	0.07	0.3217	0.0108
	Connective Tissue	4.92	5.38	5.22	5.17	5.07	5.22	0.46	0.7670	0.7689
	Off-Flavor	1.90^{b}	2.01^{ab}	1.84^{b}	1.96^{ab}	2.10a	1.85^{b}	0.02	0.2296	0.2505
	Cooking Loss	23.44	25.03	26.11	27.79	27.49	25.67	0.40	0.8005	0.9612

a, b, c, dMeans in the same row having different superscripts are significant at $P < 0.05$.
[1]Blast Frozen = spacers placed between boxes of meat and placed in a -28°C freezer with high air velocity, Conventional Frozen = boxes of meat placed in a -28°C freezer with minimal air movement, Slow Thaw = subprimals set on a table in a 0°C room for 14 days, Fast Thaw = subprimals immersed in a circulating water bath (< 12°C) for 21 hrs 14 Day Aged = Aged for 14 days and fresh, never frozen, 21 Day Aged = Aged for 21 days and fresh, never frozen.
[2]*P*-value for the interaction between Freezing process and thawing process.
Tenderness (1 extremely tough – 8 extremely tender); juiciness (1 extremely dry – 8 extremely juicy); connective tissue (1 abundant amount – 8 no connective tissue); off-flavor (1 no off-flavor – 4 strong off-flavor).

Panelists evaluated six samples (one per treatment) per session. Sensory panels were conducted in a positive pressure ventilated room with lighting and cubicles designed for objective meat sensory analysis. Each sample was evaluated for tenderness (8 = extremely tender; 1 = extremely tough), juiciness (8 = extremely juicy; 1 = extremely dry), connective tissue (8 = no connective tissue; 1 = abundant amount) and off-flavor (1 = no off-flavor; 4 = strong off-flavor).

Statistical Analysis

Purge loss, cooking loss, Warner-Bratzler shear force, and trained sensory panel data were analyzed using the PROC GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, N.C.). When significance ($P \leq 0.05$) was indicated by ANOVA, mean separations were performed using the LSMEANS and PDIFF functions of SAS. CONTRAST statements were used to see if there was significance ($P \leq 0.05$) between blast frozen and conventionally frozen as well as slow thaw and fast thaw subprimals.

Results

There were significant differences in purge loss among all of subprimals ($P < 0.0001$). Fast thawed subprimals had equal or lesser purge loss compared to the fresh never frozen subprimals. The slow thawed subprimals had the most purge loss ($P < 0.001$). There were no differences in purge loss between blast frozen and conventionally frozen subprimals ($P > 0.05$); the differences were between fast and slow thawing treatments (Table 1). The differences in purge loss between thawing treatments are likely because fast thaw subprimals were thawed to 28-30°F, and were still slightly frozen in the center when cut. The slow thawed subprimals were thawed to 32°F.

Strip loin and GM frozen steaks were all equal or superior in WBS to 14D and 21D steaks. Slow thawed steaks were equal in WBS to 14D and 21D steaks. All slow thawed steaks for the LT and LL were equal or superior ($P < 0.01$) in WBS when compared to fast thaw steaks (Table 1). There were no significant differences in WBS among treatments within the GM ($P = 0.08$).

There were few differences found in the sensory evaluation (Table 2). There were no significant difference in sensory tenderness within the LT, LL and GM ($P > 0.05$). There were no significant differences in juiciness in LL and GM steaks ($P > 0.05$). The 14D and 21D LT steaks were juicier than all frozen steaks ($P < 0.001$). The 14D and 21D LT steaks also experienced less or equal cooking loss than all frozen steaks ($P < 0.001$). There were no significant differences in cooking loss in the LL and GM. For all steaks, frozen treatments were equal to 14D steaks in connective tissue. There were no significant differences in connective tissue detected in LT and GM steaks ($P > 0.05$). Slow thawed steaks for the LL had less connective tissue than the fast thawed and 21D steaks. There was no significant difference detected in off-flavor among the treatments for the LT and LL. The CF had the strongest prevalence of off-flavor ($P = 0.02$) in the GM. Overall, neither freezing nor thawing rates had significant meaningful effects on Warner-Bratzler shear force or sensory. Freezing rate did not affect purge loss. When thaw rates are properly managed (the meat is thawed slowly or quickly and outer surface of the meat does not exceed 45°F), tenderness and sensory attributes will be comparable to fresh product.

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