1-1-2005

Evaluation and Composition of Beef *Semitendinosus* Utilizing a Novel Cooking System

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Summary

The effects of cooking dwell time on chemical and physical properties of cooked meat and cook-out purge were examined. Cooked meat yields were not affected among cooking dwell times for samples with 12% added enhancement solution. Increasing cooking dwell time resulted in increased cooked meat tenderness. No differences were demonstrated among cook-out purge samples for moisture, ash, fat, and total collagen values regardless of cooking dwell time, pump level, and endpoint temperature of the sample. This may be beneficial to meat processors in creating an ready-to-eat product that utilizes cook-out purge.

Introduction

Cook-out purge is an everyday occurrence for a meat processor, yet little is understood about the production of cook-out purge and how to utilize it. The term "cook-out purge" describes an aqueous solution, which includes water and water-soluble proteins, found after a meat product has been thermally processed in a cook-in bag. The ready-to-eat (RTE) market is an ideal opportunity for meat processors to find a method of utilizing cook-out purge. Many factors must be considered during the development of a meat RTE product such as meat tenderness, product flavor profile, ability to be re-heated or fully cooked within consumers' homes, and how other non-meat ingredients interact within the meat system. Since raw muscle, cooked meat, and cook-out purge of the meat system are related, the chemical composition of each must be examined to better understand these relationships. The focus of this research was to study how cooking dwell time affected the chemical and physical properties of beef *semitendinosus* during thermal processing. The objectives were to determine if length of dwell time during thermal processing affected chemical properties of cooked meat and cook-out purge, and to determine if altering the length of cooking dwell time affected cooked meat tenderness.

Procedure

Beef *semitendinosus* (ST) muscles (n=48) were delivered to the Loeffel Meat Laboratory at the University of Nebraska-Lincoln. The ST muscles were trimmed of external fat and connective tissue. Each ST muscle was randomly assigned a cooking dwell time (0, 60, 90, or 120 minutes) within a level of added enhancement solution (0% or 12%) and internal endpoint temperature (140ºF or 150ºF) combination. Cooking dwell time was defined as the time (in minutes) each sample was held at a designated endpoint temperature. Each sample was injected with either 0% or 12% of an enhancement solution containing 2% salt and 0.3% sodium phosphate. Each roast was then sealed in a plastic bag and tumbled for one hour in a vacuum tumbler. To ensure separation and isolation of the muscle from the cook-out purge during thermal processing, cook-in bags were modified to contain a one quart plastic bottle at the bottom of the bag to collect the cook-out purge. A stainless steel ham hook was inserted in the distal end of the muscle. A long string loop was secured to the ham hook. The meat, hook, and loop were placed into a modified cook-in bag. Each cook-in bag was sealed by clipping twice with a pneumatic clipper and hung on a cooking cart by the hook. The cook-in bags were placed in an Alkar hot water cooker that continuously showered the products with hot water. The water temperature was raised to 100ºF initially and allowed to shower samples for 30 minutes. After each 30-minute increment, the water temperature was increased 43ºF until water temperature was 160ºF. The water temperature was held at 160ºF until the first sample reached its designated internal endpoint temperature. The water temperature was then decreased to 140ºF or 150ºF, depending on designated endpoint temperature to prevent overcooking. As each sample reached its designated endpoint temperature, the cooking dwell time was initiated and monitored. Samples reaching the designated endpoint temperature and cooking dwell time were removed from the cooker and the modified cook-in bags containing the roast were placed into a stainless steel sausage truck. The bags were packed in ice and allowed to cool for a minimum of 12 hours. Following cooling, the roasts were prepared for tenderness analysis utilizing Warner-Bratzler shear force. Chemical analyses to determine moisture, ash, fat, protein, and total collagen content were conducted on the roasts and cook-out purge. Total collagen content was determined by analyzing the hydroxyproline content (mg of collagen/g). Cooking yield was

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Table 1. Cooking yields (%) for cooked beef *semitendinosus* with 0% or 12% added enhancement solution and cooked to an internal endpoint temperature of 140°F and 150°F

Endpoint	0% Enhancement Solution Dwell Time (minutes)				12% Enhancement Solution Dwell Time (minutes)			
Temperature	0	60	90	120	0	60	90	120
140°F	83.54^{a}	68.45^{b}	76.49^{a}	76.16^{a}	84.75	84.30	82.94	82.49
150°F	77.11^{a}	73.79^{b}	74.65^{ab}	70.08^{c}	81.06	78.01	77.71	78.32

^{abc}Within each pump level, means within a row having different superscripts are significantly different (P <0.05).

Table 2. Warner-Bratzler shear force values (lb) for beef *semitendinosus* with 0% or 12% added enhancement solution and cooked to internal endpoint temperature of 140°F or 150°F.

Endpoint	0% Enhancement Solution Dwell Time (minutes)				12% Enhancement Solution Dwell Time (minutes)			
Temperature	0	60	90	120	0	60	90	120
140°F	7.21^{ab}	8.14^{a}	6.04^{b}	6.70^{b}	8.86^{a}	6.24^{b}	5.71^{b}	6.68^{b}
150°F	6.61	6.61	6.55	6.39	7.29	6.83	6.70	6.42

^{ab}Within each pump level, means within a row having different superscripts are significantly different (P <0.05).

Table 3. Chemical composition of cooked beef *semitendinosus* with 0% or 12% added enhancement solution and cooked to an internal endpoint temperature of 140°F or 150°F.

	0% Enhancement Solution Dwell Time (minutes)				12% Enhancement Solution Dwell Time (minutes)			
Trait	0	60	90	120	0	60	90	120
Moisture (%)								
140°F	69.44^{a}	68.67^{a}	67.23^{b}	67.39^{b}	72.23	71.53	71.75	70.81
150°F	68.63^{a}	67.44^{b}	67.41^{b}	65.82^{c}	71.03	70.94	69.93	71.02
Ash (%)								
140°F	1.17	1.11	1.07	1.31	2.64	2.52	2.45	2.34
150°F	1.30^{b}	1.36^{a}	1.44^{a}	1.50^{a}	2.66^{a}	2.78^{a}	2.54^{b}	2.63^{a}
Fat (%)								
140°F	3.14	3.28	2.33	3.77	3.36^{a}	1.96^{b}	2.67^{ab}	2.22^{b}
150°F	2.33^{ab}	3.29^{a}	1.81^{b}	1.79^{b}	3.00	4.01	2.90	2.92
Protein (%)								
140°F	27.62^{b}	29.30^{a}	29.90^{a}	29.32^{a}	24.13^{b}	24.49^{ab}	24.07^{b}	25.72^{a}
150°F	29.37^{b}	29.84^{b}	29.83^{b}	31.86^{a}	24.35^{b}	24.78^{b}	26.23^{a}	25.05^{ab}
Total Collagen (mg/g)								
140°F	6.50	7.09	5.11	7.34	4.65	5.74	5.62	4.55
150°F	6.75	9.06	5.62	6.97	5.78	5.78	5.04	6.95

^{abc}Within each pump level, means within a row having different superscripts are significantly different (P <0.05).

measured and calculated as the difference in roast weight before and after cooking and was expressed as the percentage weight remaining.

Results

Cooked meat yields decreased for samples with an internal endpoint temperature of 150°F and 0% enhancement pump level (P <0.05) as cooking dwell times increased (Table 1). There were no differences in cooked meat yields among samples treated with the enhancement solution. The similar yields indicate that adding an enhancement solution maintains the cooking yield of meat samples over a two-hour dwell time.

Product tenderness was evaluated utilizing Warner-Bratzler shear force. Roasts cooked to an internal endpoint temperature of 150°F, regardless of added enhancement solution, did not differ among cooking dwell times (Table 2). Among enhanced samples with an endpoint temperature of 140°F, extending the dwell time to 60 minutes or more resulted in lower WBS values than samples with 0 minutes of dwell time. A similar trend was noted for 0% added enhancement at 140°F, with dwell times beyond 60 minutes.

Moisture values for cooked meat samples with 0% added enhancement solution decreased as cooking dwell time increased (Table 3). For samples with an endpoint temperature of 140°F, a significant decrease (P <0.05) in moisture levels was seen between samples with cooking dwell times 60 minutes and lower compared to those 90 minutes or greater. Moisture levels for samples with 12% added enhancement solution were not affected by cooking dwell time (P >0.05) regardless of internal endpoint temperature (Table 3). As seen in Table 1, cooked meat samples with 12% added enhancement solution had higher overall cooking yields than the 0% added enhancement solution samples, which indicates less moisture loss. Altering the ionic strength of the meat protein by adding salt and sodium phosphate likely allowed better water binding.

Ash levels for samples cooked to an endpoint temperature of 140°F, regardless of level of added enhancement solution, were unaffected (P >0.05) by cooking dwell time (Table 3). Samples with 0% added enhancement solution held for 0 minutes at 150°F had the lowest (P <0.05) ash level. As expected, ash levels were approximately twice as great for samples with 12% enhancement solution compared to those with 0%. The enhancement solution contained sodium phosphate and salt, which would increase ash levels. The ash level may appear to be increased or concentrated, when in actuality the loss of moisture during thermal processing may have changed the percentage of ash within each cooked meat sample.

The effect of moisture loss on percentage of other chemical components of cooked muscle also may be true for cooked meat fat levels. Samples containing 12% added enhancement solution and cooked to 140ºF had a range of 1.4% fat among cooking dwell times with samples held for 60 minutes having the lowest fat value (Table 3). Levels of fat did not consistently decrease as cooking dwell time increased. It was expected fat levels would decrease as cooking dwell time increased, but the varying levels of fat among dwell times can not be explained.

Protein composition of cooked meat with 0% enhancement solution increased as dwell time increased (Table 3). Samples containing 12% enhancement solution did not have a consistent increase in protein content as dwell time increased. The increased protein level among cooking dwell time may have been affected, similar to the change in ash and fat values, by the loss of moisture within the cooked meat sample.

The levels of total collagen were not affected (P >0.05) by cooking dwell time for any treatment combination (Table 3). Reports in the literature indicate that collagen solubility may occur with increased temperature and cooking dwell time, however, this was not seen in our study. Previous research has suggested that other factors besides temperature contribute to meat tenderness. Endogenous proteolytic and collagenolytic enzymes also might affect collagen solubility.

The chemical composition of cook-out purge is shown in Table 4. No differences (P >0.05) were demonstrated for moisture, ash, fat, and total collagen values regardless of cooking dwell time and treatment combination of added enhancement solution and endpoint temperature of the sample. A difference (P <0.05) of cook-out purge protein level was seen among purge samples from roasts containing 0% added enhancement solution, cooked to an endpoint temperature of 140ºF, and a dwell time of 60 minutes. The significant decrease in protein levels cannot be explained within this study. Purge samples from roasts with an endpoint temperature of 150ºF, 12% added enhancement solution, and held for 0 minutes had the lowest cook-out purge protein values among cooking dwell times within that treatment combination. The overall range of absolute protein levels was lower among purge samples from roasts containing 12% added enhancement level compared to 0%. Adding salt and sodium phosphate to cooked meat may have affected the level of protein expressed during thermal processing. Altering ionic strength within the meat and the combination of cooking dwell time and endpoint temperature may affect levels of cook-out protein levels within purge.

Table 4. Chemical composition for cook-out purge of beef *semitendinosus* with 0% and 12% added enhancement solution and cooked to an internal endpoint temperature of 140ºF and 150ºF.

	0% Enhancement Solution Dwell Time (minutes)				12% Enhancement Solution Dwell Time (minutes)			
Trait	0	60	90	120	0	60	90	120
Moisture (%)								
140ºF	95.62	96.69	95.86	95.48	95.46	98.08	96.78	95.51
150ºF	95.12	95.58	96.26	95.36	96.43	94.83	96.83	96.82
Ash (%)								
140ºF	1.09	0.97	1.31	1.34	2.47	2.25	2.51	2.54
150ºF	1.30	1.23	1.30	1.17	2.27	2.51	2.03	2.11
Fat (%)								
140ºF	0.22	1.53	0.05	0.06	1.31	0.00	0.47	0.75
150ºF	0.30	0.06	0.14	0.00	0.80	1.01	0.15	0.00
Protein (%)								
140ºF	4.46^{a}	2.16^{b}	4.72^{a}	5.02^{a}	2.26	2.83	3.39	3.47
150ºF	5.04	4.52	4.56	4.19	2.02^{b}	2.35^{a}	2.95^{a}	2.70^{a}
Total Collagen (mg/g)								
140ºF	0.71	0.04	0.72	2.31	0.53	2.12	1.94	1.78
150ºF	0.56	1.40	1.20	0.49	0.94	0.83	1.31	1.47

[ab]Within each pump level, means within a row having different superscripts are significantly different (P <0.05).

As the moisture levels of cooked meat samples decreased among cooking dwell times, the levels of other chemical components were affected. Although the differences in total collagen were not significant in this study, collagen content may be important to consumer meat quality and deserve further evaluation. No differences were demonstrated among cook-out purge samples for moisture, ash, fat, and total collagen values regardless of cooking dwell time, pump level, and endpoint temperature of the sample. This may be beneficial to meat processors in creating an RTE product that utilizes cook-out purge as the only component affected by cooking dwell time is the level of protein. The amount of protein found in cook-out purge may be affected by altering the components and levels within the enhancement solution.

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