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Factors Affecting the Sensory and Shear Properties of Pre- and Postrigor Cooked Beef Roasts

B. W. BERRY[1] and E. E. RAY[2]

[1]Meat Science Research Laboratory, SEA-AR, USDA, Beltsville, Maryland, U.S.A.
[2]Department of Animal and Range Sciences, New Mexico State University, Las Cruces, New Mexico, U.S.A.

INTRODUCTION

The immediate cooking of prerigor boned muscles or roasts would appear to offer advantages in terms of reduced energy requirements, especially for product that must be reheated or served chilled. Recent studies (Berry et al., 1980; Berry et al., 1981; Ray et al., 1980a,b,c) have indicated, however, that prerigor cooking can result in increased toughness. This toughness is probably the result of heat induced contractions of rigor during cooking. However, Berry et al. (1981) found that prerigor cooking of beef roasts could result in acceptable tenderness if the product was served in a thinly-sliced form. Method of cooking may also play an important role in regulating the ultimate tenderness of prerigor cooked beef. Ray et al. (1980a) reported lower shear force values for roasts cooked by steam or convection oven compared to roasts cooked in a hot water vat. West et al. (1980) found long time low-temperature cooking of pre-rigor roasts also produced acceptable tenderness. When cooking procedures have been employed within one and one-half hours postmortem, electrical stimulation has not exerted a beneficial effect on tenderness (Berry et al., 1980; Ray et al., 1980b). West et al. (1980) found the use of 7 or 30 days of 2° C storage coupled with electrical stimulation produced acceptable tenderness in prerigor cooked roasts.

Since tenderness problems have arisen with prerigor cooked beef, this series of studies was undertaken to determine if electrical stimulation, longer cooking times and mechanical tenderization could improve tenderness values.

EXPERIMENTAL

Electrical stimulation, muscle boning, mechanical tenderization and cooking procedures

Five separate studies were used to investigate the effects of various factors on the sensory and shear properties of pre- and postrigor cooked *semimembranosus* (SM) and *semitendinosus* (ST) muscles. Beef carcasses of USDA Good and Low Choice grades were used in these trials.

Trial I

This trial was designed to evaluate the effects of various cooking times on prerigor boned SM roasts. Fifteen beef carcasses were randomly allotted to one of 3 cooking schedules (5 carcasses per schedule) to evaluate the effects of cooking time on pre-rigor boned SM roasts. The SM from the right side of each carcass was removed at one hour post-exsanguination while the SM from the left side was removed at 48 hr post-mortem. The SM roasts were split longitudinally with one half of the roast receiving an application of commercial roast beef seasoning while the other half received no seasoning. The roasts were placed in polyvinylidene chloride bags and sealed. Roasts in all succeeding trials also were placed in cooking bags prior to cooking. Three separate cooking schedules were compared. One schedule (6 hr) consisted of cooking roasts in a hot water bath according to the following schedule: first hour at 46° C, second hour at 51° C, third hour at 57° C, fourth hour at 63° C, fifth hour at 68° C and sixth hour at 80° C until an internal temperature of 66° C was attained. A five hour (5 hr) cooking schedule consisted of the second through the sixth hour schedule of the 6 hr cooking schedule, while a four hour (4 hr) cooking schedule consisted of the third through the sixth hour schedule of the 6 hr cooking schedule. A comparison of these three cooking schedules was also made in Trials II, III and IV.

Trial II

This trial was designed to compare the effects of electrical stimulation (ES) vs nonstimulation (NS) using prerigor boned ST muscles. Again, 15 beef carcasses were used with the same 3 cooking schedules described for Trial I. ST muscles from both the right and left sides were removed from the carcasses at one hr post-exsanguination. Muscles from the right sides were ES using 50 separate 1 sec durations at 110 V.

Trial III

In this study the effects of mechanical tenderization were studied on both pre- and postrigor boned SM cooked using the three schedules previously described. Fifteen beef carcasses were used and the SM muscles were removed from the right sides one hr post-exsanguintion. The muscles were split longitudinally and one half of each muscle from each side was passed twice through a Ross blade tenderizer. The muscles from the left sides were removed from the carcasses at 48 hr postmortem, split longitudinally, with one-half of each sample being subjected to blade tenderization.

Trial IV

This trial was designed to determine the effects of ES and NS on prerigor boned ST using a five probe electrical stimulator. Muscles were removed from both sides (45 min post exsanguination) of 22 carcasses prior to stimulation. Only muscles from the right side received stimulation which consisted of 50 separate durations at 110 V. Again the muscles were allocated to the three cooking schedules previously described.

Trial V

This trial was designed to study the effects of ES and microwave cooking on sensory and shear properties of the ST muscle. Muscles from both the right and left sides of 12 carcasses were removed at 45 min post-exsanguination. Muscles from the right sides were ES using 50 separate 1 sec durations of 110 V by means of a five probe stimulator. The ST from the left side received no stimulation. The muscles were cross-sectioned into two equal portions with one portion selected at random to be held (20° C) for two hr prior to cooking, while the other portion was held for four hr prior to cooking. All roasts were cooked in a microwave oven to an internal temperature of 66° C.

In all Trials, after the cooked roasts had cooled, they were vacuum packaged and frozen at -28° C. Roasts were then transported from New Mexico State University to the Meat Science Research Laboratory, USDA, Beltsville, Maryland, for sensory and physical testing.

Sensory panel and physical evaluations

Roast sections were thawed at 3° C for 36 hr before they were served to the panelists. Thaw loss percentages were determined from pre- and post-thawing weights. Degree of doneness was scored by two evaluators using an 8-point photographic scale (8 = very rare, 1 = very well done). Samples were approximately 7° C at the time of serving. Meat cubes (1.2 cm) were served to panelists. A 10-member descriptive attribute panel trained according to procedures outlined by AMSA (1978) was used to evaluate samples. Panelists assigned scores according to the following attributes and scales: tenderness, 8 = extremely tender, 1 = extremely tough; juiciness, 8 = extremely juicy, 1 = extremely dry; connective tissue amount, 8 = none, 1 = abundant; and roast beef flavor intensity, 8 = extremely intense, 1 = extremely bland. Panelists evaluated only samples from a given trial during a session.

Samples were sheared with the Instron and Warner-Bratzler shear machines according to procedures outlined in the AMSA (1978) guidelines. All cores were 1.27 cm in diameter. Each core was sheared twice with eight cores per roast subjected to Instron maximum single blade shear force and two cores used for Warner-Bratzler shear force.

Statistical analyses

Data were analyzed according to analysis of variance procedures (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

The effects of ES on sensory and shear properties, within trials, are given in Table 1. With the exception of a lowered Instron shear force value, ES had no effect ($P>0.05$) on properties measured from muscles in Trial II. In Trial IV the only effect of ES was in producing higher juiciness scores. In comparing the results of Trial II with IV, it would appear that there are no major advantages in using multi-probe vs single probe stimulators. However, all muscles in Trials II and IV were boned prerigor. Ray et al. (1980b) found no improvement in shear force values of prerigor cooked roasts from electrically stimulated carcasses. Berry et al. (1980) found tenderness differences between pre- and postrigor cooked beef roasts to be less from sides that were ES compared to sides NS.

When the rapid microwave cooking procedure was used (Trial V), ES produced higher sensory panel ratings for tenderness, connective tissue and flavor intensity ratings as well as lower shear force values. It would appear that this method of cooking is too rapid for prerigor muscle and thus allows for heat rigor to occur. The lower thaw loss for microwave cooked roasts is probably due to so much moisture being lost during cooking. Regardless of the use or non use of ES, roasts held for 4 hr post-boning prior to cooking had higher juiciness and flavor intensity scores than roasts held for 2 hr post-boning ($P<0.05$).

With the exception of Trial I, the various cooking schedules exerted little influence on sensory and shear properties of the beef roasts (Table 2). In Trial I the longer cooking times resulted in higher tenderness scores, lower sensory panel detected connective tissue, and lower shear force values. The Instron shear values were actually significantly ($P<0.05$) affected by the interaction of boning temperature with cooking schedule. The longer cooking schedule (6 hr) produced the same mean shear values for pre- and postrigor boned roasts, while with 4 hr cooking, prerigor boned roasts had a mean shear value of 9.0 kg and postrigor boned roasts had a mean shear value of 7.1 kg. With prerigor cooked ST muscles (Trials II and IV) it would appear that the longer cooking times were ineffective in improving tenderness. However, the mean tenderness scores are all in the range of acceptability. The SM appears to produce more tender samples than the ST when subjected to prerigor cooking at any of these schedules.

Postrigor cooked SM roasts were more tender, but drier with lower shear force values than prerigor cooked SM roasts (Table 3). Previous work (Berry et al., 1980, 1981; Ray et al., 1980a,b,c) has shown similar results with prerigor cooked beef. As explained in Table 2, the higher Instron shear values for prerigor cooked roasts in Trial I was also influenced by cooking schedule. Regardless of the temperature of boning, blade tenderization resulted in higher tenderness scores, less detectable connective tissue, but slightly lower flavor intensity scores. The application of commercial roast beef seasoning (Trial I) was effective in increasing the intensity of beef flavor regardless of the state of rigor when the roasts were cooked.

In conclusion, prerigor cooked roasts generally are not as tender as postrigor cooked roasts, although acceptable tenderness can be achieved in cooking prerigor muscle, especially with the SM. Longer cooking times and blade tenderization appear useful although are not always consistent in improving the tenderness of prerigor cooked beef. The lack of significant ($P>0.05$) interactions between boning temperature and tenderness enhancement systems (ES, BT, cooking schedule) would indicate that these systems function in a similar manner in both pre- and postrigor muscle.

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Table 1. Effects of electrical stimulation on sensory and shear properties of pre- and postrigor cooked beef roasts.

Trial, muscle, stimulation[b]	Property							
	Tenderness score[a]	Connective tissue amount score[a]	Juiciness score[a]	Flavor intensity score[a]	Warner-Bratzler shear force (kg)	Instron shear force (kg)	Thaw loss (%)	Degree of doneness score[a]
II--ST								
ES	5.0	6.4	5.6	4.7	5.4	8.0[c]	13.8	4.5
NS	5.2	6.2	5.6	4.8	5.9	8.4[d]	13.5	4.7
IV--ST								
ES	5.7	6.7	5.6[c]	3.8	6.2	8.3	15.4	4.0
NS	5.6	6.7	5.3[d]	3.8	5.9	7.7	14.3	4.0
V--ST								
ES	4.8[c]	6.4[c]	5.1	4.3[c]	7.0[c]	8.3[c]	3.9	4.8
NS	4.2[d]	5.8[d]	5.2	4.1[d]	8.6[d]	10.3[d]	4.5	5.0

[a]Scoring systems based on 8 = extremely tender, juicy and intense in roast beef flavor, none in connective tissue amount and very rare in degree of doneness. 1 = extremely tough, dry and bland in roast beef flavor, abundant in connective tissue amount and well done in degree of doneness.

[b]ST = semitendinosus, ES = electrical stimulation, NS = non-stimulation. In Trial II, both sides were hot-boned and one probe was used for ES. In Trial IV both sides were hot-boned and five probes were used in ES. In Trial V both sides were hot-boned and roasts were cooked by microwave procedures.

[c,d]Means in the same column in the same Trial bearing different superscripts are significantly different ($P<0.05$).

Table 2. Effects of cooking time on sensory and shear properties of pre- and postrigor cooked beef roasts.

Trial, muscle, cooking schedule[b]	Tenderness score[a]	Connective tissue amount score[a]	Juiciness score[a]	Flavor intensity score[a]	Warner-Bratzler shear force (kg)	Instron shear force (kg)	Thaw loss (%)	Degree of doneness score[a]
	Property							
I--SM								
6 hr	6.9[c]	7.4[c]	5.2	4.0	4.1[c]	5.9[c]	7.9	4.5
5 hr	6.3[c]	7.1[c]	5.2	3.9	5.2[d]	6.9[c,d]	6.1	4.6
4 hr	5.4[d]	6.8[d]	5.6	4.1	6.0[d]	7.9[d]	6.5	4.6
II--ST								
6 hr	5.2	6.5	5.7	4.8	5.7	8.0	12.5	4.3
5 hr	5.1	6.3	5.6	4.7	5.4	8.1	15.2	4.7
4 hr	5.1	6.2	5.8	4.7	5.9	8.4	13.3	4.7
III--SM								
6 hr	6.0	6.9	5.2	4.8	3.8	5.2	13.1	4.0
5 hr	6.0	6.7	5.4	4.6	3.8	5.5	13.3	4.0
4 hr	6.2	7.0	5.5	4.8	3.6	4.8	16.2	4.3
IV--ST								
6 hr	5.9	6.8	5.5	3.8	5.5	7.4	14.5[c,d]	4.2
5 hr	5.3	6.6	5.4	3.6	5.9	8.1	11.4[c]	4.0
4 hr	5.5	6.7	5.4	4.1	6.8	8.9	18.1[d]	3.8

[a]Refer to Table 1.

[b]6 hr cooking schedule = first hr at 46° C, second hr at 51° C, third hr at 57° C, fourth hr at 63° C, fifth hr at 68° C, sixth hr at 80° C until an internal temperature of 66° C was reached. 5 hr cooking schedule = second through sixth hour schedule of 6 hr cooking schedule. 4 hr cooking schedule = third through sixth hour schedule of 6 hr cooking schedule. In Trial I, one side was hot-boned and one side was cold-boned.

[c,d]Means in the same column in the same Trial bearing different superscripts are significantly diffferent ($P<0.05$).

Table 3. Effects of boning temperature and mechanical tenderization on sensory and shear properties of pre- and postrigor cooked beef roasts.

Trial, muscle, temperature, tenderization[b]	Tenderness score[a]	Connective tissue amount score[a]	Juiciness score[a]	Flavor intensity score[a]	Warner-Bratzler shear force (kg)	Instron shear force (kg)	Thaw loss (%)	Degree of doneness score[a]
	Property							
I--SM								
HB	6.0[c]	7.0[c]	5.6[c]	4.0	5.5[c]	7.5[c]	6.2	4.8[c]
CB	6.4[d]	7.2[d]	5.1[d]	4.0	4.7[d]	6.4[d]	7.5	4.3[d]
III--SM								
HB	5.8[c]	6.9	5.7[c]	4.8	4.1[c]	5.6[c]	13.1	4.0
CB	6.3[d]	6.9	5.0[d]	4.6	3.3[d]	4.7[d]	15.3	4.2
BT	6.4[c]	7.2[c]	5.4	4.6[c]	3.6	5.1	14.5	4.3
NBT	5.7[d]	6.6[d]	5.3	4.8[d]	3.8	5.2	13.9	3.9

[a]Refer to Table 1.

[b]BT = blade tenderization; NBT = not blade tenderized; HB = hot boned; CB = cold boned.

[c,d]Means in the same column within temperature or tenderization categories bearing different superscripts are significantly different ($P<0.05$).