January 2002

The Effects of Marination and Cook Cycles on High and Low pH Beef Muscles

Ryan Baumert
University of Nebraska-Lincoln

Roger W. Mandigo
Universit y of Nebraska - Lincoln, rmandigo1@unl.edu

The Effects of Marination and Cook Cycles on High and Low pH Beef Muscles

Ryan Baumert
Roger Mandigo[1]

Muscles of the chuck and round vary in pH. Muscles with high pH values can be used more effectively in a marination system than muscles with low pH values.

Summary

Infraspinatus and Serratus ventralis, the muscles of the high pH group, had lower shear force values and higher sensory analysis scores for tenderness, juiciness and overall acceptability than low pH muscles (Deep pectoral and Biceps femoris). Increasing the phosphate level in the marination system increased moisture content of the cooked roast and sensory juiciness scores and decreased the cooking loss of the roasts. Low humidity cookery had higher sensory juiciness, tenderness and acceptability scores and lower cooking losses than high humidity cookery. The Infraspinatus and Serratus ventralis are recommended for use in a marination system with low humidity cookery.

Introduction

With the growing popularity of ready-to-eat food, enhanced (injected) beef products will be produced on a larger scale in coming years. Chemical and physical properties of the muscles of the chuck and round have been studied in recent years. These studies have produced information that will be valuable for the development of value-added beef products. Success of an enhanced and marinated beef product will lie with the muscle characteristics and ingredients used in the marinade. Ingredients such as phosphates increase the water retention of meat products. Increasing the water retention of the meat helps to hold the natural water of the meat and added marinade solution, to produce a juicy cooked product. Therefore, the objectives of this project were to increase precooked roast beef palatability and consistency by targeting pH differences in specific chuck and round muscles and evaluating high and low humidity cookery systems.

Procedures

This study examined four muscles (Infraspinatus, Serratus ventralis, Deep pectoral, Biceps femoris), three phosphate levels (0%, 0.25%, 0.5%), two cooking humidity levels (high and low), and two endpoint internal temperatures (140°F and 160°F). The Infraspinatus and Serratus ventralis were categorized as high pH muscles (pH >5.75) and the Deep pectoral and Biceps femoris were categorized as low pH muscles (pH <5.75). 144 roasts were marinated and cooked in three production days.

Boxed beef containing the specified muscles was purchased from the ConAgra Beef Company at Grand Island, Neb. and shipped to the University of Nebraska Loeffel Meat Lab. External fat and heavy external connective tissue were removed from the four muscle groups. Muscles were then sectioned into approximately four pound roasts and assigned to treatments. Roasts were injected with a marinade solution containing water, salt, flavorings and either 0, 0.25, or 0.5% phosphate. Roasts were pumped to approximately 10% above green weight and placed in a vacuum sealable bag. The remaining portion of solution for a 12% pickup was added to the bag. Bags were vacuum sealed and double bagged with the second bag having no vacuum. Treatments were tumbled for 30 minutes. Roasts were cooked in either a high humidity oven (100% RH) or low humidity oven (33% RH) to an endpoint internal temperature of 140°F or 160°F. The roasts were then cooled overnight and the following day weights were taken for determination of cooking loss and samples were taken for chemical and physical testing.

Proximate composition was conducted to determine moisture, fat, ash, and protein content of the samples. Total collagen content was determined by analyzing the hydroxyproline amount (mg of collagen/g) in the samples of sample. A 1-inch thick sample was taken from each cooled roast for analysis of

(Continued on next page)

tenderness using Warner-Bratzler shear force. The pH of the raw and cooked roasts was determined for initial categorization and change in pH. Eight consumer taste panels consisting of approximately 30 faculty, staff, graduate and undergraduate students of the university (each session) were conducted to look at tenderness, juiciness, and overall acceptability of the sample roasts. An 8-Point Hedonic scale was used with a score of 8 being extremely desirable and a score of 1 being extremely undesirable. Each panelist received a plate of six samples (1" x .5" x .25") to compare at each session.

Statistical analyses of the data were performed to study the fixed effects and interactions at P< 0.05. This was done using the Proc Mixed and LS Means procedure of SAS.

Results

Data collected for pH on the raw muscles showed significant differences between the muscles within the pH categories (Table 1). High pH muscles (Infraspinatus, Serratus ventralis) had significantly higher pH values (P< 0.001) than the low pH muscles (Deep pectoral, Biceps femoris). These data support information reported in the literature. The pH of the cooked muscles was significantly affected by muscle, phosphate level, humidity level, and end point internal temperature (Table 2). The differences between muscles remained similar to those observed with the initial pH of the raw muscles. By increasing the phosphate level in the product, the pH rose slightly but significantly (P< 0.05). Increasing the humidity level during cooking slightly raised the pH (P< 0.01), as did the 160°F endpoint internal temperature (P< 0.05).

Cooking loss of roasts was affected by phosphate level, humidity level, and endpoint internal temperature (Table 3). Increasing the phosphate level reduced cooking loss significantly between 0% and 0.25% (P< 0.0001). There was a decrease in cooking loss at the 0.5% level, but it was not significantly different from the 0.25% level. The low humidity cookery had significantly lower cooking loss (P<0 .001), as did the 140°F end point internal temperature (P< 0.0001).

The tenderness values determined by the Warner-Bratzler shear force test (Table 4) indicated significant differences between muscles within and between pH categories (P< 0.01). Tenderness scores (Table 5) collected during the taste panel sessions also showed significant differences between muscles within and between pH categories (P< 0.0001). Low humidity cookery revealed significantly higher tenderness scores than the high humidity cookery (P< 0.001). Sensory juiciness scores (Table 5) were significantly affected by muscle, phosphate level, humidity level, and end point internal temperature (P< 0.0001). High pH muscles were significantly juicier

Table 1. Initial pH of raw muscles.

	Initial pH	
Muscle	Mean	(S.D.)
Infraspinatus	5.80[a]	(0.207)
Serratus ventralis	5.87[a]	(0.133)
Deep pectoral	5.69[b]	(0.055)
Biceps femoris	5.64[b]	(0.060)

[ab]Means with different superscripts are different (P< 0.001).

Table 2. Cooked meat pH affected by treatments.

	Cooked meat pH	
Treatment	Mean	(S.D.)
Infraspinatus	6.06[a]	(0.177)
Serratus ventralis	6.07[a]	(0.104)
Deep pectoral	5.97[b]	(0.071)
Biceps femoris	5.95[b]	(0.081)
0.0% phosphate	5.98[c]	(0.104)
0.25% phosphate	6.02[d]	(0.105)
0.5% phosphate	6.05[d]	(0.107)
High humidity	6.03[a]	(0.104)
Low humidity	5.99[b]	(0.109)
140°F	5.99[c]	(0.100)
160°F	6.03[d]	(0.113)

[ab]Means with different superscripts are different (P< 0.01)
[cd]Means with different superscripts are different (P< 0.05)

Table 3. Cooking losses of sample roasts affected by treatments.

	Cooking loss (%)	
Treatment	Mean	(S.D.)
0.0% phosphate	28.17[a]	(4.64)
0.25% phosphate	22.63[b]	(5.35)
0.5% phosphate	23.52[b]	(6.31)
High humidity	26.73[c]	(5.54)
Low humidity	22.82[d]	(5.82)
140°F	22.56[a]	(5.01)
160°F	26.94[b]	(6.01)

[ab]Means with different superscripts are different (P< 0.0001)
[cd]Means with different superscripts are different (P<0 .001)

Table 4. Warner-Bratzler shear force values for individual muscles.

	Pounds of Force	
Muscle	Mean	(S.D.)
Infraspinatus	3.68[a]	(0.405)
Serratus ventralis	4.98[b]	(0.464)
Deep pectoral	12.00[c]	(1.590)
Biceps femoris	7.27[d]	(0.936)

[abcd]Means with different superscripts are different (P< 0.01)

Table 5. Sensory analysis scores affected by different treatments.

	Juiciness		Tenderness		Acceptability	
Treatment	Mean	(S.D)	Mean	(S.D)	Mean	(S.D)
Infraspinatus	5.39[a]	(1.40)	5.73[a]	(1.45)	5.44[a]	(1.48)
Serratus ventralis	5.56[a]	(1.50)	5.49[b]	(1.65)	5.29[a]	(1.64)
Deep pectoral	4.98[b]	(1.82)	4.14[c]	(1.82)	4.32[b]	(1.75)
Biceps femoris	4.79[b]	(1.63)	4.54[d]	(1.83)	4.51[b]	(1.82)
0.0% phosphate	4.92[a]	(1.61)	4.88	(1.91)	4.72	(1.79)
0.25% phosphate	5.26[b]	(1.44)	5.06	(1.79)	4.97	(1.70)
0.5% phosphate	5.36[b]	(1.54)	5.01	(1.79)	4.99	(1.73)
High humidity	5.04[a]	(1.55)	4.86[e]	(1.81)	4.77[e]	(1.73)
Low humidity	5.31[b]	(1.52)	5.10[f]	(1.84)	5.02[f]	(1.76)
140°F	5.37[a]	(1.49)	5.04	(1.84)	4.98	(1.74)
160°F	4.98[b]	(1.57)	4.92	(1.82)	4.81	(1.74)

[abcd]Means with different superscripts are different (P< .0001).
[ef]Means with different superscripts are different (P< .001)
Means with no superscripts are not significantly different.

than low pH muscles. Increasing the phosphate level increased juiciness scores. Significantly higher scores for the low humidity and 140°F end point temperature were observed. Sensory acceptability (Table 5) of the roasts was significantly higher for high pH muscles (P<0.0001) and low humidity cookery (P<0.001).

The results of this study show that an acceptable enhanced beef product can be produced if high pH muscles, such as the Infraspinatus and Serratus ventralis, are marinated with a 0.25% phosphate level and cooked to 140°F in a low humidity cookery system. This will allow the beef industry to help recapture value being lost in the chuck and round.

[1]Ryan Baumert, graduate student, Roger Mandigo, professor, Animal Science, Lincoln.