Hydrodyne-Treated Beef: Tenderness, Rancidity, and Microbial Growth

B.M. O'Rourke, C.R. Calkins, R.T. Rosario, M.B. Solomon, and J.B. Long

University of Nebraska, Lincoln, USA, USDA, ARS, Meat Science Lab., Beltsville, MD, USA, and Hydrodyne, Inc., San Juan, PR, USA.

INTRODUCTION

Tenderness is the primary factor determining palatability and overall consumer satisfaction of meat. The current inconsistency in beef tenderness creates significant customer concern. Therefore, technologies to enhance tenderness offer considerable opportunities to improve product quality and customer satisfaction.

In the Hydrodyne process, vacuum packaged meat is placed within a stainless steel hemispherical tank and immersed in water. Detonation of a small amount of explosive within the water generates a shock wave which penetrates the meat, strikes the sides of the tank, and reflects back through the meat. The entire process takes place in an encapsulated steel tank to contain the explosion and the resulting water splash.

The shock wave generates up to 6.9 MPa of force which appears to cause substantial damage to muscle structure and results in an immediate and significant reduction in shear force. One reason for the effectiveness of the technique is the acoustical match between the liquid medium (water) and meat. Connective tissues and bone seem less affected by the process.

Severe disruption of the muscle ultrastructure might be expected to contribute to enhanced proteolysis and oxidation, creating enhanced tenderness but reduced retail storage life. This research was conducted to determine the effect of the Hydrodyne process on tenderness, oxidative rancidity, and microbial growth during storage and retail display of beef.

MATERIALS AND METHODS

Sixteen beef strip loins and 16 rounds (8 Control [C] and 8 Hydrodyne [H] each) were selected, vacuum packaged, and shipped to the Hydrodyne facility for testing. Five days postmortem, the meat was placed within the hemispherical tank and the tank was filled with water. The explosive mixture was positioned in the water 56 cm from the bottom of the tank and detonated. The resulting shock force was estimated to be 4.1 MPa.

All meat was then transported to the Beltsville Agricultural Research Center in Beltsville, MD and representative samples were removed, repackaged and shipped on ice to the University of Nebraska. Following shipping, strip loins were sampled (day 7), repackaged in vacuum and stored an additional 10 days before sampling during the beginning and end of a retail display period. Top rounds were sampled (day 10), packaged and stored an additional 7 days before sampling as previously described. Analysis on strip loins included: Warner-Bratzler shear force (d7, 17), cooking loss (d7, 17), cooking time (d7, 17), pH (d7, 17, 21), sarcomere length (d7), purge (d7, 17), TBARS (thiobarbituric acid - reactive substances, d 7, 17, 21), total plate count (d7, 17, 21) and anaerobic plate count (d7, 17, 21). Analysis on top rounds included: purge (d10, 17), purge volume (d10), pH (d10, 17, 21), TBARS (d10, 17, 21), total plate count (d10, 17, 21), and anaerobic plate count (d10, 17, 21).

A pH probe was used to make the pH measurements. Sarcomere length samples were hardened in formaldehyde and measured by laser diffraction. Purge weight was collected by weighing the vacuum packaged bags and then subtracting the weight of the meat and bag. Volume of purge was also recorded. Oxidative rancidity was followed by TBARS. Microbial analysis was obtained by 6.45 square cm random swabs on each meat cut aseptically and recorded as colony forming units (cfu) per 6.45 square cm area. For aerobic plate counts, plates were incubated 48 hrs at 0 C. Aerobic numbers were determined by incubating samples under anaerobic conditions for 48 hr at 2 C. For retail display, samples were randomly positioned in the retail case and relocated each day. Samples were at 4 C with light ranging from 20-50 foot candles. Strip loins were cooked on Open Hearth Farberware broilers to an internal temperature of 70 C and as many 1.27 cm diameter cores were obtained as possible (8-10 cores). The cores were sheared parallel to the long axis of the muscle fiber. Cooking loss and cooking time were also obtained.

RESULTS

Hydrodyne treatment of the strip loins caused a significant decline in shear force (Table 1) measured two days later (7 days postmortem). This was an immediate and meaningful decline. An extended aging period, including five days of retail display, removed the tenderness benefits of the process (no difference in shear force). In an earlier paper with pork chops (paper in preparation), we demonstrated a similar effect. It is interesting to note that shear force was generally acceptable in all samples (<3.5 kg), yet Hydrodyne still proved beneficial. Previous research on the process indicated that over-tenderization does not seem to occur and that tough longissimus muscles seem to benefit more from Hydrodyne treatment than tender longissimus muscle. These data suggest that aging may allow untreated meat to reach a similar level of tenderness. A study to compare aging time and Hydrodyne treatment is needed to determine the extent to which tenderness benefits from the Hydrodyne process supersede the benefits of aging. Insufficient samples were collected from the round to permit an assessment of shear force in these muscles.

No differences among the treatments were consistently found in muscle pH, sarcomere length, or purge for either cut. All samples exhibited a high amount of purge, probably due to temperature fluctuations during the shipping period. This may have masked

any treatment differences.

It was anticipated that Hydrodyne treatment might enhance oxidative rancidity. In this study, extended retail display after an extended storage period increased the amount of thiobarbituric acid-reactive substances (Table 1,2). However, no differences among treatments were revealed. There was a trend for Hydrodyne-treated strip loins to have a lower TBARS readings after extended retail display, but this difference was not consistent enough to be different. Thus, it appears that the Hydrodyne process does not compromise rancidity, which implies flavor stability. In a companion study (data not shown), the color stability of the two cuts did not differ between Hydrodyne treatment and control.

Previous research suggested a slight but significant reduction in microbial numbers when the Hydrodyne process was applied. A similar trend was noted for aerobic plate count in the strip loin and round samples, but this was attributable to a single sample of each muscle with a much higher count than all other samples, regardless of treatment (Table 1,2). No credible reason could be found for excluding the data points. As expected, the number of anaerobic micro-organisms declined during retail display. No differences were detected at the initiation or the conclusion of the retail display period. After storage and shipping, however, the Hydrodyne-treated rounds possessed slightly, but significantly, higher numbers of anaerobic microbes - which did not carry through. It should be noted that in all cases, the numbers were extremely low (<400 cfu/6.45 square cm).

CONCLUSION

These data suggest that Hydrodyne treatment results in an immediate and significant enhancement of beef tenderness and that no detrimental effects of the process are evident in measures of rancidity or microbial stability.

Table 1. Characteristics of Hydrodyne - Treated Beef Strip Loins.

	Time post-mortem					
	d7		d17		d21	
Trait	C[a]	H[a]	C	H	C	H
Shear force, kg	3.23[c]	2.81[d]	2.54[d]	2.65[d]	-	-
TBARS[b]	.36[c]	.34[c]	.20[c]	.21[c]	1.28[d]	.83[d]
Aerobic plate count, cfu/6.45 cm^2	457.5[c]	237.5[c]	327.5[c]	333.8[c]	2831.3[d]	780.6[c]
Anaerobic plate count, cfu/6.45 cm^2	348.1[c]	395.6[c]	92.8[d]	33.0[d]	76.0[d]	36.5[d]

[a] C = Control (untreated); H = Hydrodyne - Treated.
[b] TBARS = Thiobarbituric acid - reactive substances.
[c,d] Means in the same row bearing different superscripts are different ($P < .05$).

Table 2. Characteristics of Hydrodyne - Treated Beef Rounds.

	Time post-mortem					
	d7		d17		d21	
Trait	C[a]	H[a]	C	H	C	H
TBARS[b]	.25[c]	.26[c]	.18[c]	.32[c]	1.37[d]	1.48[d]
Aerobic plate count, cfu/6.45 cm^2	386.9[c]	192.5[c]	312.5[c]	105.6[c]	2982.1[c]	448.8[c]
Anaerobic plate count, cfu/6.45 cm^2	25.8[c]	172.5[d]	52.9[c]	26.5[c]	8.8[c]	27.3[c]

[a] C = Control (untreated); H = Hydrodyne - Treated.
[b] TBARS = Thiobarbituric acid - reactive substances.
[c,d] Means in the same row bearing different superscripts are different ($P < .05$).