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Tenderness and Retail Stability of Hydrodyne-Treated Beef

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The potential exists to use an explosively-generated shock wave in water to tenderize beef. No detrimental changes to product display or shelf stability characteristics are created by the Hydrodyne process.

Summary

Detonating a small explosive within a water-filled, stainless steel tank, creates a shock wave which penetrates vacuum-packaged meat. The acoustical match between water and meat caused an immediate and significant (P<.05) reduction in shear force. After an additional 10 days of aging, no tenderness differences (P>.05) were detected. Hydrodyne created no differences in pH, sarcomere length, purge, oxidative rancidity, bacterial counts (anaerobic or aerobic) or panel color ratings for either cut. Treated samples had higher Hunter L values. The Hydrodyne process can tenderize unaged meat with no detriment to product display or shelf stability characteristics.*

Introduction

Tenderness, the primary factor determining palatability and overall consumer satisfaction of meat, is inconsistent, creating significant consumer concern. Therefore, technologies to enhance tenderness can improve both 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 10,000 psi of force which appears to cause immediate and significant reduction in shear force. One reason for the technique's effectiveness is the acoustical match between the liquid medium (water) and the meat, which is 70-75% water. 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

Table 1. Characteristics of Hydrodyne-treated beef strip loins and top rounds.

	Strip loins - time post-mortem						Top Rounds - time post-mortem					
	d7		d17		d21		d10		d17		d21	
Trait	C[a]	H[a]	C	H	C	H	C	H	C	H	C	H
Shear force, lb	7.12[c]	6.20[d]	5.60[d]	5.84[d]	—	—	—	—	—	—	—	—
TBARS[b]	.36[c]	.34[c]	.20[c]	.21[c]	1.28[d]	.83[d]	.25[c]	.26[c]	.18[c]	.32[c]	1.37[d]	1.48[d]
Aerobic plate count, cfu/in^2	73.2[c]	38.0[c]	52.4[c]	53.4[c]	453.0[d]	124.9[c]	61.9[c]	30.8[c]	50.0[c]	16.9[c]	477.1[c]	71.8[c]
Anaerobic plate count, cfu/in^2	55.7[c]	63.3[c]	14.8[d]	5.3[d]	12.2[d]	5.8[d]	4.1[c]	27.6[d]	8.5[c]	4.2[c]	1.4[c]	4.4[c]

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

tenderness, oxidative rancidity, color and microbial growth during storage and retail display of beef.

Procedure

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 (Buena Vista, VA) for testing. Five days postmortem, the meat was placed within the water-filled hemispherical tank. The explosive mixture (ammonium nitrate and nitromethane) was positioned in the water 18 in. from the bottom of the tank and detonated. The resulting shock force was estimated to be 4,000 psi.

All meat was then transported to the Beltsville Agricultural Research Center in Beltsville, Maryland and representative samples were removed, repackaged and shipped on ice to the University of Nebraska, Lincoln, Nebraska. Samples were taken at three different periods: after shipping, after storage and after retail display. Following shipping, strip loins were sampled (day 7), repackaged in vacuum and stored an additional 10 days at 40°F 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 of pH, purge, thiobarbituric acid-reactive substances (TBARS), aerobic plate count and anaerobic plate count were conducted after a shipping period, at the beginning and at the end of a retail display period (day 7, 17, 21 for strip loins and day 10, 17, 21 for top rounds). Panel discoloration scores (lean color, surface uniformity and surface discoloration) and Hunter colorimeter lab values were obtained for both cuts each day of the retail display period. Warner-Bratzler shear force (day 7, 17) and sarcomere length (day 7) were collected only on strip loins.

For retail display, samples were randomly positioned in the retail case and repositioned each day. Samples were maintained at 40°F with light ranging from 20-50 foot candles. Strip loin steaks were broiled to an internal temperature of 158°F and as many .5- in 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 recorded.

Results

Hydrodyne treatment of the strip loins caused a significant decline in shear force (Table 1) measured two days after treatment (7 days postmortem). This was an immediate and meaningful decline. An extended aging period (17 days postmortem), removed the tenderness benefits of the process (no difference in shear force). It is interesting to note that shear force was generally acceptable in all samples (<7.72 lbs), yet Hydrodyne still proved beneficial. Previous research on the process indicated over-tenderization does not seem to occur and that tough longissimus muscles seem to benefit more from Hydrodyne treatment than tender longissimus muscles. These data suggest 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 of aging supersede the benefits from the Hydrodyne process. Insufficient samples were collected from the top 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 before retail storage. All TBARS (a measure of rancidity) were below 0.4. This is well below 1.0, the point at which rancidity is usually detected. In this study, extended retail display after an extended storage period increased the amount of thiobarbituric acid-reactive substances (Table 1). However, no differences among treatments were revealed for either cut (.34 [H] vs .36 [C] in strip loins, d7 and .26 [H] vs .25 [C] in top rounds, d10). 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 significant (.83 [H] vs 1.28 [C] for the strip loins (P>.05) and 1.48 [H] vs. 1.37 [C] for the top rounds (P>.05). Thus, it appears the Hydrodyne process does not compromise rancidity, which impacts flavor stability.

It should be noted that while microbial numbers were extremely low (<500 cfu/square in), in all cases, the Hydrodyne-treated rounds possessed slightly, but significantly, higher

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numbers of anaerobic microbes after storage and shipping, which did not carry through retail display. Previous research suggested a slight but significant reduction in microbial numbers when the Hydrodyne process was applied. A similar trend noted for aerobic plate count in the strip loin and round samples was attributable to a single sample of each muscle with a much higher count than all other samples, regardless of treatment (Table 1). 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.

Lean color, surface uniformity and surface discoloration panel scores revealed no differences among treatments in either cut. Hunter color L* values were higher in the Hydrodyne strip loins and top rounds, indicating Hydrodyne was slightly lighter ($P<.05$) than the control (43.84 [H] vs. 41.70 [C] for the strip loins and 45.34 [H] vs. 44.53 [C] for the top rounds). These data indicate the Hydrodyne process can tenderize unaged meat with no detriment to product display or shelf stability characteristics. Further study on the process is needed to clarify the Hydrodyne/aging relationship and to refine the technique prior to commercialization.

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