51st International Congress of Meat Science and Technology
August 7-12, 2005 – Baltimore, Maryland USA

EFFECT OF HYDRODYNAMIC PRESSURE TREATMENT BEFORE PROCESSING ON PORK HAM QUALITY

J.A. Callahan*, M.N. Liu, and M.B. Solomon

USDA†, Agricultural Research Service, Beltsville, MD, USA

Key Words: ham, hydrodynamic pressure process, further processed

Introduction

The tenderizing effect of the hydrodynamic pressure process (HDP) has been studied in a variety of fresh and frozen/thawed meats. A small amount of explosive, suspended above the meat, is detonated to create a shock wave that tenderizes meat as a result of microscopic tears in the myofibrillar structure (Zuckerman and Solomon, 1998). Very little research has evaluated the tenderization and quality effects of HDP in further processed meat products (Senecal et al., 2001; Schilling et al., 2002). When HDP was applied to beef semitendinosus, which was then subjected to freeze-drying and stored 60 days (37.8°C), HDP treatment reduced shear stress and increased the percent rehydration (9.9%) of freeze-dried meat compared to the control (Senecal et al., 2001). Schilling et al. (2002) HDP treated beef biceps femoris before processing into frankfurters and found no difference between control and HDP treated samples for color, cook yield, protein solubility or textural properties. The hams used for this preliminary experiment were part of a larger study involving transgenic and dietary conjugated linoleic acid (CLA) supplemented pigs. Eastridge et al. (2001) reported that neither gene (IGF-I transgene) or diet (CLA) affected pork loin quality parameters (ultimate muscle pH, amount of purge during storage, TBARS malonaldehyde formation during storage, cook yield, and shear force).

Objectives

The objective of this study was to determine the effect of HDP treatment (before processing) on the processing, water holding capacity, color, and textural properties of smoke-cooked ham.

Methodology

Hams for this study were obtained from IGF-I transgenic and control pigs fed a diet supplemented with 2% corn oil (control) or with 1% corn oil and 1% CLA-60 until 120 kg target weight. The pigs were slaughtered on site under humane conditions (USDA Abattoir #68, Beltsville, MD). The carcasses were chilled at 3°C for 48 hours. A 15 cm section of ham was removed from the bone at the largest area of the leg. The green hams were packaged in 3 mil high performance vacuum packaging bags (Model 030044, Koch, Kansas City, MO), frozen and stored at -24°C. A total of sixteen hams were chosen such

that transgene and diet factors of the study were balanced. For each genetic/diet group, HDP treatment was assigned to two hams and the remaining two hams served as controls. Due to the size of the ham and the multiple muscles it contained, it was not possible to have a paired control for each treated ham.

For each of two processing days (replications), eight frozen hams were thawed for 5 days at 2°C. The external skin and fat were removed from all meat samples. Two hams designated for HDP treatment were vacuum packaged into a single bone guard bag (Model B650TBGW, Cryovac©/Sealed Air Corp., Duncan, SC) and briefly heat shrunk (91°C). A single package was placed onto a 1.3 cm thick flat metal reflector plate inside a water filled 98-L plastic explosive container (Rubbermaid Inc., Wooster, OH) for each of two HDP treatments. A 100 g binary explosive (cylinder shape) was suspended 31 cm above the meat and detonated to create the shock wave treatment. Control hams were kept at 2°C during HDP treatment.

After HDP treatment, control and HDP hams were injected using a three prong needle with brown sugar cure (Palmer House, Waterloo, IA) brine to 115% target weight. All hams were placed in the vacuum tumbler (Model ET-3, Sipromac, Quebec, Canada) and tumbled 15 minutes on and 15 minutes off (9 RPM) for a total of 2 hours. Brined hams were kept at 2°C for 12-14 hours and then placed into heavy weight poly smoking nets (Model 260700455, Koch Supplies, North Kansas City, MO). The hams were natural smoke-cooked to 68.3°C in the smokehouse (Model 700 HP, Alkar, Lodi, WI) using the Alkar schedule: boneless hams, netted, heavy smoke, conditioning step (Alkar Operations and Maintenance Manual, Process Schedules, Section 4, page 3). Immediately after cooking, the hams were placed in the 2°C cooler overnight. The hams were vacuum packaged in 3 mil bags and stored (2°C) for 5 days. After storage, the hams were cut into three 2.5 cm thick slices. Two slices were packaged individually in 3 mil vacuum packaging bags and stored (2°C) until needed for textural evaluation. The third slice was immediately analyzed for color, water holding capacity (WHC) and fat and moisture analysis.

During processing, weights were recorded for the following processing parameters. Percent brine uptake was determined by the difference between after and before tumbling weights. Smoke-cook loss was the weight lost between tumbling and smoking. Processing yield was determined by the weight difference between after 18 hr chilling and original ham weight. 18 hr chilled purge was determined between the weights after 18 hr storage and the smoke-cook process. The 5 days storage purge was determined by the difference between the weights of 5 days storage and the 18 hr storage.

The ham slice designated for color, WHC and moisture and fat analysis was placed on a plastic tray and covered with All-Purpose Food Wrap (Polyvinyl Films, Inc., Sutton, MA) to allow blooming of the hams at room temperature (25°C) for 1 hour. A minimum of six color measurements were taken on each slice with a Chroma Meter (Model CR-200, Minolta Camera Co., Ltd, Osaka, Japan). WHC was measured on a minimum of three 2.5 cm diameter, 10 g ham cores as described by Desmond et al. (2000) with modifications. For centrifugation, two absorbent pieces of paper (Kimwipes, Kimberly-Clark, Neenah, WI) were placed in the bottom of the centrifuge tube and covered with a Whatman #1 filter paper disk (2.6 cm diameter). Soxhlet fat and moisture analysis was determined with the remaining sample.

Ham slices were randomly assigned to instrumental analysis using the Warner-Bratzler Shear Test (WBS, AMSA, 1995) or Texture Profile Analysis (TPA, Bourne, 1978). A minimum of six cores were removed using a 1.3 cm diameter corer parallel to the direction of the muscle fibers for WBS and measured on the Universal Instron Testing Machine (Model 1122, Canton, MA) using a 100 kg load cell with a crosshead speed of 250 mm/min. Ham cores (2.5 cm diameter, 2.0 cm thick) were compressed to 50% of original height two times for TPA using the Universal Instron Testing Machine (crosshead speed 50 mm/min, 7.5 cm diameter compression platen). TPA parameters calculated were hardness, cohesiveness, springiness, chewiness, and gumminess.

Ham processing parameters, color, and textural instrumental analysis were analyzed using SAS® (Version 9.1, SAS Institute Inc., Cary, NC, 2002-2003) PROC MIXED with a model that included animal as a random effect and fixed effects were HDP treatment, gene, and diet. Least square means for HDP treatment and control were separated using pairwise t-tests (LSMEANS/DIFFS option).

Results & Discussion

Since testing parameters were not affected with any practical significance by genetic background or diet, only HDP treated vs. control effects are presented. HDP treated hams were not found to be different ($P>0.05$) than the controls for processing parameters (Table 1). Senecal et al. (2001) reported that the rehydration rate was increased by 9% on semitendinosus muscle treated with HDP, freeze dehydrated and rehydrated on day 0 compared to controls. The percent rehydration increased to 10% on freeze dehydrated meat stored 60 days (37.8°C) and rehydrated. For this ham study, the water holding capacity was slightly but not significantly higher for HDP treated hams than controls. It also was noted in Senecal and coworkers' research that percent cook loss was reduced 2 to 4% for HDP treated samples. In the present study, the smoke-cook loss was slightly but not significantly higher for HDP treated hams than from controls.

The surface color of the ham slices were not significantly different for L, a*, and b* due to HDP treatment (Table 2). These results are similar to previous studies evaluating color parameters (Schilling et al., 2002; Berry et al., 1999). No differences in finished product color were found for beef treated with HDP prior to processing into frankfurters (Schilling et al., 2002). Berry et al. (1999) found that color properties of ground beef patties were not affected when the lean and fat materials were HDP treated. No significant differences were found for fat and moisture content for treated and control hams (Table 2).

WBS force values and TPA parameters are presented in Table 3. No significant differences were found for WBS values. TPA springiness was higher ($P<0.05$) for the control hams in comparison to the hams treated with HDP. Springiness is the ability for the sample to recover its height from the first compression to the second (Bourne, 1978). A possible explanation for the inability of the HDP treated sample to return to its original form could be due to the microscopic tearing of the myofibrillar structure that occurs during HDP (Zuckerman and Solomon, 1998). No other TPA parameters, hardness, cohesiveness, chewiness and gumminess, were significantly affected by the HDP treatment. Initially these ham samples were tender before HDP treatment with WBS values less than 2.0 kgf. Thus, any HDP treatment improvements for tenderness/texture

may be difficult to detect. These textural results are in agreement with Schilling et al. (2002) who did not find any differences for TPA parameters between frankfurters made with either HDP treated biceps femoris or controls. In contrast, Berry et al. (2000) reported ≥40% tenderness improvement for HDP treated freeze dried beef and beef and chicken sticks which improved in tenderness as a result of HDP treatment.

Conclusions

Hams processed from HDP treated muscles were not different from the controls for any of the processing parameters that are of interest to ham manufacturers. No detectable differences were found for water holding capacity, color or chemical analysis. HDP treatment did not affect textural properties with the exception of TPA springiness. These results indicate that use of HDP before processing hams does not adversely or favorably affect ham quality.

References

AMSA. 1995. Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness Measurements of Fresh Meat. Am. Meat Sci. Assoc. and Nat. Live Stock and Meat Board, Chicago.

Berry, B.W., Solomon, M.B., Bigner-George, M.E., and Eastridge, J.S. 1999. Application of Hydrodyne technology for ground beef. J. Anim. Sci. 77 (Suppl. 1), 91.

Berry, B.W., Solomon, M.B., and Senecal, A.G. 2000. Application of hydrodynamic pressure processing for further processed meat products. J. Anim. Sci. 83 (Suppl. 1), 161.

Bourne, M.C. 1978. Texture Profile Analysis. Food Technology, 33(7), 62–66, 72.

Desmond, E.M., Kenny, T.A., Ward, P. and Sun, D-.W. 2000. Effect of rapid and conventional cooling methods on the quality of cooked ham joints. Meat Sci. 56, 271–277.

Eastridge, J.S., Solomon, M.B., Pursel, V.G., Mitchell, A.D. and Arguello, A. 2001. Dietary conjugated linoleic acid and IGF-I transgene effects on pork quality. J. Anim. Sci. 80 (Suppl 1), 20.

Schilling, M.W., Claus, J.B., Marriott, N.G., Solomon, M.B., Eigel, W.N. and Wang, H. 2002. No effect on hydrodynamic shock wave on protein functionality of beef muscle. J. Food Sci. 67(1), 335–340.

Senecal, A.G., Racicot, K., Segars, R. Berry, B., and Solomon, M. 2001. Effect of hydrodynamic pressure processing on freeze-dried whole muscle semitendinosus. 2001 Annual Meeting Book of Abstracts, Abstract #30C-3, 61.

Zuckerman, H. and Solomon, M.B. 1998. Ultrastructural changes in bovine longissimus muscle caused by the Hydrodyne process. J. Muscle Foods, 9, 419–426.

† Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

Tables and Figures

Table 1. Mean values[a] (standard errors) for the effects of hydrodynamic pressure processing (HDP) for processing parameters[b] and water holding capacity

Treatment	Percent Brine Uptake	Smoke-cook Loss	Processing Yield	18 hr Chilled Purge	5 Day Storage Purge	Water Holding Capacity
Control	11.61	24.57	82.02	3.37	0.93	87.97
	(0.84)	(1.50)	(1.90)	(0.18)	(0.09)	(0.57)
HDP	11.01	26.15	80.44	3.47	0.95	88.33
	(0.84)	(1.50)	(1.90)	(0.18)	(0.09)	(0.55)

[a]Means without any superscripts within a column are not significantly different at α=0.05.

[b]Ham processing parameters were percent brine uptake, processing yield, smoke-cook loss, processing yield, 18 hr chilled purge, 5 day storage purge.

Table 2. Mean values[a] (standard errors) for the effects of hydrodynamic pressure processing (HDP) for smoke-cooked ham color and chemical analysis

	Color			Chemical Analysis	
Treatment	L	a*	b*	% Moisture	% Fat
Control	61.65	11.26	12.02	64.07	9.19
	(1.54)	(0.34)	(0.13)	(0.97)	(1.01)
HDP	61.06	11.52	11.79	65.80	6.67
	(1.53)	(0.34)	(0.13)	(0.97)	(1.01)

[a]Means without any superscripts within a column are not significantly different at α=0.05.

Table 3. Mean values (standard errors) for the effects of hydrodynamic pressure processing (HDP) for Warner-Bratzler shear force (WBS) and Texture Profile Analysis

		Texture Profile Analysis				
Treatment	WBS (kgf)	Hardness (kgf)	Cohesiveness	Springiness (mm)	Chewiness (kgf mm)	Gumminess
Control	1.77	10.87	0.45	0.61[a]	2.96	4.95
	(0.04)	(0.66)	(0.01)	(0.01)	(0.17)	(0.29)
HDP	1.84	12.21	0.44	0.57[b]	3.07	5.41
	(0.04)	(0.60)	(0.01)	(0.01)	(0.19)	(0.32)

[ab]Means with different letters within a column are significantly different at α=0.05.