

Research Notes

Effects of Post-Mortem Time Before Chilling and Chilling Temperatures on Water-Holding Capacity and Texture of Turkey Breast Muscle¹

M. T. LESIAK,* D. G. OLSON,^{†,2} C. A. LESIAK,* and D. U. AHN[†]

*Campbell Soup Company, Farmington, Arkansas 72730, and

[†]Department of Animal Science, Iowa State University, Ames, Iowa 50011

ABSTRACT Two studies were conducted to determine 1) the effect of post-mortem time before chilling on hot boned prerigor breast muscle water-holding capacity (WHC), and 2) post-mortem temperature effect on sarcomere length and drip loss of uncooked breast, and shear force and WHC of turkey breast muscle that is hot-boned, marinated, and cooked. In Study 1, the turkey breast muscle was excised immediately after slaughter and chilled at 0 C. The effect of post-mortem time (15, 30, 45, 60, 90, and 120 min) before chilling on muscle pH, drip loss, and WHC (measured by homogenate cooking yield) was determined. In Study 2, hot boned prerigor breast slices were held at either 0 or 12 C and then at 3 h post-mortem stored at 2 C. Sarcomere length and drip loss of uncooked breast, and the shear force and WHC (measured by cooking yield)

of cooked breast muscles with water, salt, and sodium tripolyphosphate were determined.

Results indicated that pH on Day 1 post-mortem and cooking yield of water homogenates were not influenced by the post-mortem time before chilling. Drip losses increased as the post-mortem time before chilling was increased. Cooking yield of homogenate with water, salt, and sodium tripolyphosphate was decreased when breast muscle was chilled after 60 min post-mortem. Drip loss of breast was less at 0 C than at 12 C, but cooking yield and shear force were not affected by post-mortem chilling temperature. It was concluded that the post-mortem time before chilling has an influence on uncooked and cooked muscle WHC, but the differences found in uncooked muscle drip loss were not reflected in WHC or shear force of cooked muscle with water, salt, and sodium tripolyphosphate added.

(Key words: post-mortem time, chilling temperatures, water-holding capacity, tenderness, turkey breast)

1997 Poultry Science 76:552-556

INTRODUCTION

Changing from conventional, cold boning poultry processing to hot-boning methods has gained interest because of potential savings in labor, space, and energy requirements (Lyon and Hamm, 1986). The process of hot boning involves removing muscle from the bone while it is at, or near, body temperature. Because of increased toughness associated with hot boning, the effects of post-mortem temperature and storage time on toughening (Hamm, 1983; Lyon and Hamm, 1986), and the texture characteristics of muscle have been investigated (Smith *et al.*, 1969; Kim *et al.*, 1986).

Honikel *et al.* (1981) reported that when beef muscle was exposed to temperatures above 25 C, or below 4 C, greater muscle shortening occurred and was found to be directly related to greater amounts of muscle drip loss. Post-mortem temperature and hot boning effects on

poultry meat characteristics have been investigated (Smith *et al.*, 1969; Kim *et al.*, 1986), but the effects on water-holding capacity (WHC) are not well understood. In turkey thigh muscle, 0 C chilling resulted in greater drip loss than chilling at 12 C, but the greatest drip losses were observed at 30 C. Greater drip loss and lower homogenate cooking yields were observed for turkey breast muscle held at 30 C post-mortem, whereas 0 and 12 C minimized water losses (Lesiak *et al.*, 1996). Northcutt *et al.* (1994) also reported that chicken meat exposed to high temperature (40 to 41 C) lost significant amounts of drip during the processing period.

In changing to a hot boning process, the post-mortem time before chilling would change from the conventional cold boning system. It is important to understand the effect of post-mortem time before chilling on WHC to design a hot boning system. In addition to post-mortem time, chilling temperature is important because boning could influence how soon muscle is chilled. Although better WHC for excised turkey breast was observed at 0 and 12 C than at 30 C (Lesiak *et al.*, 1996), it is likely that texture would be altered by chilling temperature. However, it is unclear whether toughness would be a concern at colder temperatures of hot boned muscle if

Received for publication April 1, 1996.

Accepted for publication October 19, 1996.

¹Journal Paper Number J-16256 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa. Project Number 0177.

²To whom correspondence should be addressed.

the muscle were to be further processed (processing beyond cut-up parts; i.e., brine addition and cooking). With increased production of further processed poultry products, it is essential to understand the influence of post-mortem temperature of hot boned muscle on toughness when the muscle is further processed.

The purposes of this study were to determine 1) the effect of post-mortem time before chilling on hot boned breast muscle WHC with and without added salts, and 2) the effect of post-mortem chilling temperature on shear force and WHC of hot boned turkey breast muscle that is cooked.

MATERIALS AND METHODS

Treatments and Sample Preparation

Live, tom turkeys weighing 11.4 to 13.6 kg were obtained from a local producer, transported to the Iowa State University Meat Laboratory, and held 14 h without feed and water. At the time of slaughter the birds were placed in a restraining cone, stunned (2 to 3 s at 120 V, 60 cycle, and set at 1.2 amp) using an electric knife (The Stunner, Model NO. FS-3671)³ and a knife cut made for carotid artery bleeding. Post-mortem time started after a 3-min bleeding period. Immediately after bleeding, the birds were skinned, and the *Pectoralis major* muscles were removed. Five birds were used in each of three replications (total of 15 birds per treatment). Two studies were conducted on the breast muscles to determine the effect of post-mortem time before chilling on WHC and the post-mortem temperature on shear force of hot boned turkey breast muscle.

Study 1

Post-mortem times before chilling were 15, 30, 45, 60, 90, and 120 min. Using *P. major* muscle from one side of each bird, muscle strips (12 strips per breast) approximately 50 mm long, 33 mm wide, and 10 mm thick were removed from the skin side of the muscle immediately after slaughter. Muscle strips were randomly placed in a single layer into labeled Nasco Whirl-Pak bags,⁴ sealed after evacuation, and then submerged in a 30 C water bath at 14 min post-mortem to maintain a constant muscle temperature. At 15, 30, 45, 60, 90, and 120 min post-mortem, duplicate bags were transferred to a 0 C water bath. At 3 h post-mortem the samples were transferred to a 2 C cooler. These muscle strips were used for drip-loss. After muscle strips used for drip-loss measurements were removed, the remaining breast muscle was cut into approximately 10-mm-thick slices starting at the anterior

(neck) end of the muscle and progressing to the posterior (tail) end. The slices were randomly loaded in a single layer, into six labeled bags and then placed in a 30 C water bath at 14 min post-mortem. At 15, 30, 45, 60, 90, and 120 min, one bag of slices was transferred to a 0 C water bath. At 3 h post-mortem, the bagged slices were transferred to a 2 C cooler. Six to 8 h post-mortem, the slices in each bag were trimmed of fat and ground twice through a 3-mm plate. Fluid exudate inside the bags from the muscle slices was mixed back into the ground samples, which were then held in a 2 C cooler. The ground breast slices were used for WHC measurements.

At 24 h post-mortem, drip loss was determined. Initial muscle strip weight was determined by bag and content weight minus bag weight. The muscle strip was blotted dry with a paper towel to remove drip loss and then weighed to determine muscle strip weight. Percentage drip loss was calculated by subtracting the muscle strip weight from the initial weight, multiplying by 100, and then dividing by the initial weight. Triplicate pH readings were taken on the 10 mm-thick strip from each breast muscle by inserting a pencil tip style combination pH probe electrode⁵ directly into the muscle strips at 15, 30, 45, 60, 90, and 120 min post-mortem time before chilling and at approximately 24 h post-mortem on the ground breast.

Cooking losses were determined for two types of homogenate as a measure of WHC of muscles chilled at 15, 30, 45, 60, 90, and 120 min post-mortem. The first homogenate (HW) contained 24 g of ground muscle and 12 g of water (2 C). The second homogenate (HWSP) contained 24 g of ground muscle and 12 g of a solution (2 C) of water, salt (sodium chloride), and sodium tripolyphosphate (STPP). The HWSP salt and STPP concentrations were 1.5 and 0.5% of the homogenate weight, respectively. Homogenates were made by placing the meat and water or water, salt, and STPP solution into a 180-mL Nasco Whirl-Pak bag and then agitating the contents by using a Stomacher-type action.⁶ Approximately 6 g of each homogenate, in duplicate, was placed into preweighed 10-mL Kimax test tubes and reweighed. The tubes were capped by using marbles and at 1 h after homogenization (held at 2 C cooler), the tubes were placed in a 90 C water bath. After 20 min, the samples were removed and allowed to cool to room temperature (1 h). Free juice was drained, and the cooked meat piece was blotted by using a paper towel. The meat piece was placed back in the tube and reweighed. Percentage cooking yield was determined by dividing the cooked meat weight by the raw homogenate weight and multiplying by 100. This procedure is similar to the method used by Honikel *et al.* (1981).

Study 2

Post-mortem chilling temperatures of 0 and 12 C were used to evaluate chilling temperature effect. From the remaining *P. major* breast muscle of each bird, four slices

³Cervin Automated Systems Inc. (currently, Midwest Processing), Minneapolis, MN 55410.

⁴Nasco, Fort Atkinson, WI 53538-0901.

⁵Laboratory Research Products, Lincoln, NE 68501.

⁶Seward Laboratory, London, UK SE1 1PP.

TABLE 1. Mean pH¹, Day 1 drip loss, and homogenate² cooking yield for various post-mortem times before chilling³

Post-mortem time before chilling (min)	pH	Drip loss	Cooking yield	
			HW	HWSP
15	6.22	0.50 ^d	64.95	80.92 ^a
30	6.02	0.88 ^c	64.19	80.92 ^a
45	6.02	0.93 ^c	64.38	80.29 ^a
60	5.94	1.17 ^{bc}	64.00	80.32 ^a
90	5.90	1.37 ^b	64.16	79.18 ^b
120	5.80	1.60 ^a	63.55	78.78 ^b
SE	. . .	0.11	0.31	0.28

^{a-d}Means in each column with no common superscript differ significantly ($P < 0.05$); $n = 15$.

¹pH at the corresponding time post-mortem (mean pH at 24 h post-mortem was 5.57).

²Homogenate HW contained water, and HWSP contained water, salt, and sodium tripolyphosphate.

³Drip loss and cooking yields were determined on Day 1 post-mortem.

(2.6 cm thick) were taken parallel to and starting at the ventral (keel) edge of the muscle. Individual slices were loaded into labeled 11 × 25 cm Cryovac bags (Type B450)⁷ and placed in either a 0 or 12 C water bath at 15 min post-mortem. Placement of the first slice alternated between the two temperatures, and adjacent slices were placed in different temperature water baths. At 3 h post-mortem, the samples were transferred to a 2 C cooler.

At 24 h post-mortem drip loss was determined. Initial muscle slice weight was determined by bag and content weight minus bag weight. The muscle slice was blotted dry with a paper towel to remove drip loss and then weighed to determine muscle slice weight. Percentage drip loss was calculated by subtracting the muscle slice weight from the initial weight, multiplying by 100, and then dividing by the initial weight. After drip loss determinations, muscle slices were stored in a 2 C cooler for sarcomere length measurement at 24 h post-mortem. Approximately 0.2 g of muscle from random locations in the muscle slice were homogenized with 10 mL of 0.05 M phosphate buffer (pH 7.1). Homogenization was performed in a 50-mL Nalgene tube by using a Brinkmann homogenizer⁸ (model PT10/35) with a setting of 8 for 5 s. Sarcomere length was measured by using a phase-contrast microscope equipped with an eye-piece micrometer at a magnification of 500×.

On Day 1 post-mortem after sampling for sarcomere length, a solution (2 C) of water, salt, and STPP was added to the bagged breast slice to prepare samples for cooking loss. Solution was added at a ratio of 0.25 parts to 1 part muscle. The bag was sealed and the bag contents were massaged by hand for 30 s. The final mixture contained 1.5% salt and 0.5% STPP. Samples were held in a 2 C cooler for 20 h; then, the bag contents were massaged again for 30 s. Bagged slices were placed on racks, which had a spacing

of 2.6 cm, and put into a 78 C water bath. Samples were removed when the slice internal temperature reached 72 C. After cooling to room temperature, the bags were opened, and the free juice was drained. The cooked muscle slice was blotted with a paper towel and weighed. The percentage cooking yield was determined by multiplying the cooked slice weight by 100 and then dividing by the raw slice plus the added solution weight.

Cooked slices were sampled at room temperature by using a 12.7-mm circular bore to determine shear force. The Warner-Bratzler shear apparatus⁹ had a blade thickness of 1.1 mm, a blade gap of 2.4 mm, and a blade speed of 2.8 mm/s. Eight sample cores from each slice were sheared across the length of the core and peak kilograms per 12.7-mm core diameter was recorded. The high and low values from each slice were eliminated to reduce any outlier effect.

Statistical Analysis

Percentage drip loss, percentage cooking yield HW, and HWSP, and Warner-Bratzler shear force were analyzed by a randomized design. When a significant value ($P < 0.05$) was found, a LSD was calculated to determine differences between the post-mortem times. Analyses of variance and LSD were completed using SAS[®] (SAS Institute, 1985) procedures. No mean separation technique was used on pH and sarcomere length values.

RESULTS AND DISCUSSION

Study 1

Breast muscle pH declined from 6.22 at 15 min post-mortem to 5.80 at 120 min post-mortem and then to 5.57 on Day 1 (approximately 24 h) post-mortem. Previous work showed that temperature affected the rate of pH decline but did not influence the ultimate muscle pH (Honikel *et al.*, 1981). Dunn *et al.* (1995) reported that the broiler carcasses chilled rapidly in water at 0 C produced tender

⁷Cryovac/Div. W. R. Grace and Co., Duncan, SC 29334.

⁸Brinkmann Instruments, Co., Div. of Sybron Corp. Westbury, NY 11590.

⁹The GR Electric Manufacturing Co., Manhattan, KS 60502.

TABLE 2. Mean sarcomere length, drip loss, cooking yield, and shear force of breast muscle at various post-mortem temperatures

Water bath temperature ¹	Sarcomere length	Drip loss	Cooking yield	Shear force
(C)	(μm)	(%)		(kg)
0	1.73	0.53 ^b	82.19	2.58
12	1.77	0.76 ^a	82.72	2.42
SE	0.07	0.05	0.41	0.08

^{a,b}Means in each column with no common superscript differ significantly ($P < 0.05$); $n = 15$.

¹Samples were held in a 2 C cooler after 3 h post-mortem.

breast meat, and the cooking loss of the breast muscle was strongly related to the pH of the muscle at 24 h post-mortem. As post-mortem time before chilling increased, drip loss increased (Table 1). Previous work with breast muscle indicated that a post-mortem temperature of 30 C increased drip loss as compared with 0 and 12 C post-mortem temperatures (Lesiak *et al.*, 1996). This result would indicate that the sooner post-mortem muscle temperatures are lowered, the less drip loss will occur.

No difference was found in HW cooking yields due to post-mortem time before chilling (Table 1). These results are similar to those of previous work, which indicates that post-mortem temperature does not have an influence on muscle and HW cooking yields (Honikel *et al.*, 1981). Post-mortem time before chilling influenced HWSP cooking yields. No difference in HWSP was detected for chilling initiation times from 15 to 60 min or between 90 and 120 min (Table 1). The largest reduction occurred between 60 (pH 5.94) and 90 min (pH 5.90) (Table 1). When the homogenates were made on Day 1 post-mortem, no treatment differences in pH existed (data not shown). In poultry, a post-mortem pH of 5.9 or higher has been used as an indicator of prerigor muscle conditions (Froning and Neelakantan, 1971), and the damaging effects of high temperature on tenderness have been related to pH values of 5.9 or higher (Khan, 1971). Previous work with turkey breast has shown that a post-mortem temperature of 30 C caused a reduction in cooking yields of homogenates containing water, salt, and STPP (Lesiak *et al.*, 1996). These observations would indicate that muscle temperature at the onset of rigor is a main factor altering cooking yields of homogenates containing water, salt, and STPP. The HWSP cooking yield differences occurred during a particular post-mortem time period, whereas significant changes in drip loss occurred throughout the post-mortem period. This finding indicates that different mechanisms exist that influence drip loss and cooking yields.

Study 2

No differences in cooking yield and shear force were found between the two chilling temperatures, but drip loss was lower at 0 C than at 12 C (Table 2). A previous study also found lower drip loss at 0 C than at 12 C (Lesiak *et al.*, 1996). Difference in shear forces due to shortening may have been minimized by water, salt, and phosphate

addition. Other researchers have found that salt and phosphate improved tenderness (Goodwin and Maness, 1984; Mathusa and Janky, 1984; Lyon and Hamm, 1986).

These results indicate that the post-mortem time before chilling has an influence on uncooked and cooked muscle WHC. In addition, the differences found in uncooked muscle drip loss due to post-mortem temperatures of 0 and 12 C was not reflected in WHC or shear force of cooked muscle containing added water, salt, and STPP.

ACKNOWLEDGMENTS

The authors thank Oscar Mayer Foods Corp., Madison, WI 53707 for partial support of the study. We also thank the Ellsworth, IA 50075 group of Louis Rich Inc. for their cooperation and assistance in obtaining birds for the study.

REFERENCES

- Dunn, A. A., D. J. Kilpatrick, and N.S.F. Gault, 1995. Contribution of rigor shortening and cold shortening to variability in the texture of *Pectoralis major* muscle from commercially-processed broilers. *Br. Poult. Sci.* 36:401-413.
- Froning, G. W., and S. Neelakantan, 1971. Emulsifying characteristics of pre-rigor and post-rigor poultry muscle. *Poultry Sci.* 50:839-845.
- Goodwin, T. L., and J. B. Maness, 1984. The influence of marination, weight, and cooking technique on tenderness of broilers. *Poultry Sci.* 63:1925-1929.
- Hamm, D., 1983. Techniques for reducing toughness in hot-stripped broiler meat. *Poultry Sci.* 62:1430. (Abstr.)
- Honikel, K. O., C. Fischer, A. Hamid, and R. Hamm, 1981. Influence of post-mortem changes in bovine muscle on the water-holding capacity of beef: Post-mortem storage of muscle at 20 C. *J. Food Sci.* 46:1-6.
- Khan, A. W., 1971. Effect of temperature during post-mortem glycolysis and dephosphorylation of high energy phosphates on poultry meat tenderness. *J. Food Sci.* 36:120-121.
- Kim, J. W., D. L. Fletcher, and D. R. Campion, 1986. The influence of stunning, high temperature aging and hot deboning on the enzyme activity, myofibrillar proteins and sarcomere length of broiler breast muscle. *Poultry Sci.* 65:176. (Abstr.)
- Lesiak, M. T., D. G. Olson, C. A. Lesiak, and D. U. Ahn, 1996. Effects of post-mortem muscle temperature and storage time on the water-holding capacity of turkey breast and thigh muscles. *Meat Sci.* 43:291-299.

- Lyon, B. G., and D. Hamm, 1986. Effects of mechanical tenderization with sodium chloride and polyphosphates on sensory attributes and shear values of hot-stripped broiler breast meat. *Poultry Sci.* 65:1072-1707.
- Mathusa, M. S., and D. M. Janky, 1984. Effects of salt brine chilling and hot boning on tenderness of canned fowl light meat. *Poultry Sci.* 63:1930-1934.
- Northcutt, K. J., E. A. Foegeding, and F. W. Edens, 1994. Water-holding properties of thermally preconditioned chicken breast and leg meat. *Poultry Sci.* 73:308-316.
- SAS Institute, 1985. SAS® User's Guide: Statistics. Version 5 Edition. SAS Institute Inc., Cary, NC.
- Smith, M. C., Jr., M. D. Judge, and W. J. Stadelman, 1969. A "cold shortening" effect in avian muscle. *J. Food Sci.* 34: 42-46.