Effect of Deboning Time, Muscle Tensioning, and Calcium Chloride Marination on Texture Characteristics of Chicken Breast Meat[1]

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ABSTRACT Tenderness is the most important organoleptic characteristic of meat, and various methods have been developed to improve it. The purpose of this experiment was to evaluate the effect of different conditioning treatments of broiler carcasses on pH, cooking losses, shear values, R-values, and sensory tenderness of breast meat. All measurements were collected for breast muscle as follows: after 24 h of carcass aging (T1); after 24 h of carcass aging with muscle tensioning (T2); after 24 h of carcass aging with muscle tensioning, followed by muscle collection and marination in $CaCl_2$ (T3); after hot-boning 15 min following slaughter (T4); after hot-boning 15 min following slaughter and marination in $CaCl_2$ (T5). pH values in meat treated with $CaCl_2$ were significantly lower than those in untreated meat from the aged carcass group (T3) or the hot-boning group (T5). Breasts from carcasses aged for 24 h (T1, T2, and T3) showed lower cooking loss than breasts harvested immediately after slaughter (T4 and T5). $CaCl_2$ marination produced meats with cooking losses significantly higher than those observed for untreated meats. Regardless of muscle tensioning or marination treatments, aging of the carcass for 24 h (T1, T2, and T3) produced meats with lower shear values than those from hot-boned carcasses (T4 and T5). Hot-boned breasts treated with $CaCl_2$ (T5) were judged less tender by panelists than breasts aged under muscle tensioning (T2 and T3).

(*Key words*: chicken breast meat, tenderness, deboning time, calcium chloride)

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INTRODUCTION

Marketing of chicken parts is one of the fastest growing segments of the food industry around the world. Special interest in this area is partially due to the convenience and nutritional value of cuts such as chicken breasts and thighs. Early collection of meat from carcass (hot-boning), however, has induced some preoccupation about texture and juiciness characteristics of filets and other breaded types of chicken portions. Toughness of cooked broiler breast meat continues to be a problem for processors, and postchill deboning time is the most significant factor on the ultimate texture of intact breast meat (Lyon et al., 1998). Because chilling is an important cost to the industry, several treatments have been proposed to minimize or reduce the toughness of chicken meat collected soon after slaughtering. Some methods have been developed to reduce broiler carcass toughness in the industry. Young et al. (1991) and Young and Lyon (1997) reported the infusion of meats in $CaCl_2$ solution as a way to accelerate postmortem tenderization. According to these authors, treatment of early harvested breast meat with $CaCl_2$ would reduce toughness due to the activation of muscle Ca-dependent proteases (calpains). Tensioning of the breast muscles through wing restraint has been proposed to improve the texture of broiler meat (Lyon et al., 1992; Janky et al., 1992; Cason et al., 1997; and Veeramuthu and Sams, 1999). Pulling the wings behind the back of the carcass and securing them causes a tensioning or stretching of the pectoralis major muscles. The result of this treatment is that less force is necessary to shear the cooked meat, and postmortem aging time may be reduced (Cason et al., 1997). Janky et al. (1992) observed that shear values for breast fillets harvested 1.25 h postmortem from muscle-tensioned carcasses were significantly lower than shear values of cooked fillets harvested at a similar time postmortem from conventionally handled broiler carcasses. The objective of this work was to study the effect of deboning time, carcass muscle tensioning, and $CaCl_2$ marination on texture characteristics of chicken breast meat.

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Abbreviation Key: ATP = adenosine triphosphate; T1 = carcass aging for 24 h at 0 C; T2 = carcass aging for 24 h with muscle tensioning at 0 C; T3 = carcass aging for 24 h with muscle tensioning at 0 C, followed by marination in $CaCl_2$ solution; T4 = hot-boning breast collection (15 min after slaughter); T5 = hot-boning breast collection (15 min after slaughter) and marination in $CaCl_2$ solution.

TABLE 1. Comparison of treatment means or grouped treatment means by orthogonal contrast analysis for pH, cooking losses, shear force, and R-values of broiler breast meat[1]

Variables	Orthogonal contrasts (P > F)			
	C1[2]	C2[3]	C3[4]	C4[5]
	Effect of deboning time	Effect of carcass wing restraint	Effect of $CaCl_2$ on muscle tensioning carcasses	Effect of $CaCl_2$ on hot deboned meat
pH (units)	NS	NS	0.05	0.05
Cooking losses (%)	0.05	NS	0.01	0.01
Shear force (kg – f)	0.01	NS	NS	NS
R-Value (units)	0.01	NS	NS	NS

[1]T1 = 24-h carcass aging; T2 = 24-h carcass aging with muscle tensioning; T3 = 24-h carcass aging with muscle tensioning and $CaCl_2$ marination; T4 = hot-boning; and T5 = hot-boning and $CaCl_2$ marination.

[2]C1 = (T4 + T5) vs. (T1 + T2 + T3).

[3]C2 = (T1) vs. (T2 + T3).

[4]C3 = (T2) vs. (T3).

[5]C4 = (T4) vs. (T5).

MATERIALS AND METHODS

One hundred male Hi-y broilers, 47 d of age, were hung on metallic funnels and killed by bleeding for 90 s from a single cut that severed the carotid artery and jugular vein.

After bleeding, birds were scalded at 65 C for 45 s, defeathered in a rotary drum picker for 35 s, and manually eviscerated. Fifty birds were used to determine meat pH, cooking losses, and shear force. Meat R-value and sensory tenderness were determined with the other 50 birds. All analyses were made on breast meat that was subjected to one of the following treatments: T1, carcass aging for 24 h at 0 C before breast collection; T2, carcass aging with muscle tensioning for 24 h at 0 C before breast collection; T3, carcass aging with muscle tensioning for 24 h at 0 C, with breast collection followed by marination in $CaCl_2$ solution; T4, hot-boning breast collection (15 min after slaughter); or T5, hot-boning breast collection (15 min after slaughter) and marination in $CaCl_2$ solution.

Carcasses subjected to muscle tensioning (T2 and T3) were kept with the wings tied back to restrain the pectoralis major muscle. Breasts treated with $CaCl_2$ (T3 and T5) were submersed in 0.3 *M* $CaCl_2$ solution in individual plastic containers for 1 h. After collection, skinless breast samples were packaged in plastic bags and were kept on ice until analysis on the same day.

Meat pH was measured in the right breast by direct insertion of an electrode[3] into the raw meat according to Young and Lyon (1997). Cooking losses were calculated after draining the plastic bags where the meat had been cooked in boiling water for 20 min (Young and Lyon, 1997). Shear force was measured with 1.9-cm samples of cooked meat using a Warner-Bratzler device.[4] R-values (inosine:adenosine ratio) were measured according to Honikel et al. (1981). Briefly, the procedure was to extract the nucleotides in 1 *M* $HClO_4$ and then observe the ratio of light absorption at 250 and 260 nm. Sensory evaluation of tenderness was conducted with cooked meat cubes (1.9 cm per side) (Lyon and Lyon, 1990). An ordination sensory test was conducted according to Stone and Sidel (1985).

Statistical Analysis

pH, cooking losses, shear force, and R-values were subjected to ANOVA. Treatment means were grouped and compared by orthogonal contrast analysis, according to the general linear models (GLM) procedures of the SAS Institute (1996), as follows: C1 = T1, T2, and T3 versus T4 and T5; C2 = T1 versus T2 and T3; C3 = T2 versus T3; C4 = T4 versus T5 (Table 1). Sensory data were analyzed using the Friedman test (Snedecor and Cochran, 1967). Statements of statistical significance were based on $P < 0.05$.

RESULTS AND DISCUSSION

Meat pH

According to Young and Lyon (1997), after slaughter the pH of chicken meat rapidly decreases from values close to neutrality to pH 5.6 to 5.8 in 6 to 8 h. In this study, pH values varied from 5.83 in meats from aged carcasses to 6.09 in hot-boned meat (Figure 1). Marination in $CaCl_2$ significantly decreased pH values of breasts collected from aged carcasses and from hot-boned birds (Table 1). Young and Lyon (1997), however, found no effect of $CaCl_2$ treatment on pH of broiler breast meat. Although Sams et al. (1990) reported that hot-boned fillets had significantly higher pH values than fillets separated after aging of a carcass, no effect of deboning time was observed in this study (Table 1). Also, muscle tensioning had no effect on pH of broiler breast meat.

[3]Hanna Instruments Model 8417, Singapore.

[4]Warner-Bratzler, Chatillon, Manhattan, KS.

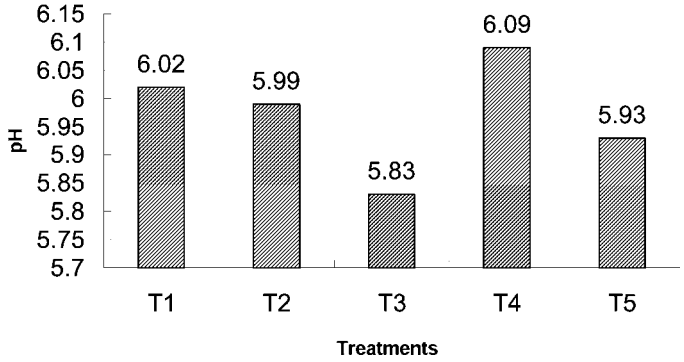

FIGURE 1. pH values from broiler breast meat collected after different treatments. T1 = Carcass aging; T2 = carcass aging with muscle tensioning; T3 = carcass aging with muscle tensioning and $CaCl_2$ marination; T4 = hot-boning breast collection; and T5 = hot-boning breast collection and $CaCl_2$ marination.

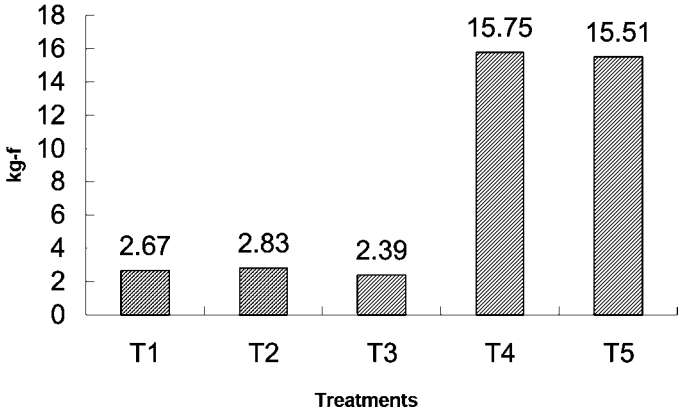

FIGURE 3. Shear force values of broiler breast meat collected after different treatments. T1 = Carcass aging; T2 = carcass aging with muscle tensioning; T3 = carcass aging with muscle tensioning and $CaCl_2$ marination; T4 = hot-boning breast collection; and T5 = hot-boning breast collection and $CaCl_2$ marination.

Cooking Losses

Breasts from carcasses aged 24 h had lower cooking losses than breasts harvested immediately after slaughter (Table 1). Figure 2 shows that meats treated with $CaCl_2$ had greater cooking losses than untreated meats (Table 1). Young and Lyon (1997) have reported similar results. According to these authors, cooking losses are often ascribed to pH effects. Young et al. (1991) also observed higher cooking losses from fillets treated with divalent cations (such as $CaCl_2$) than from untreated fillets. Muscle tensioning had no effect on the broiler breast cooking losses.

Shear Values

Figure 3 shows that carcass aging for 24 h before breast collection produced meat with lower shear values than that from hot-boned carcasses (Table 1). These results agree with observations made by Sams et al. (1990). These authors found that hot-boned broiler breast fillets were significantly tougher (increased shear values) than chill-boned fillets. Papa and Lyon (1989) reported that for breast muscles removed from the skeleton prior to the depletion of adenosine triphosphate (ATP), the subsequent contraction would result in cooked meat that is tough. Muscle tensioning and $CaCl_2$ treatment, however, had no effect on chicken breast shear value. Janky et al. (1992) observed that carcass muscle tensioning resulted in a significant reduction in shear values of broiler breast meat. Young et al. (1991) reported that $CaCl_2$ marination of prerigor broiler fillets reduced the Warner-Bratzler shear value.

R-Value

The R-value corresponds to the ratio of the concentration of various adenine phosphatidyl compounds (ATP, adenosine diphosphate, adenosine monophosphate, and others) to that of a major breakdown product, inosine

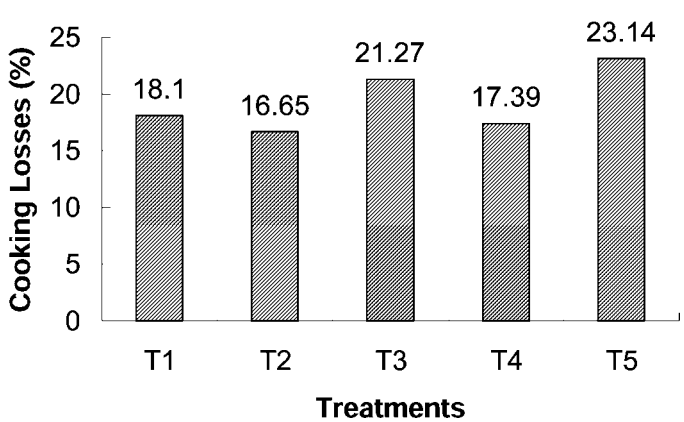

FIGURE 2. Cooking losses from broiler breast meat collected after different treatments. T1 = Carcass aging; T2 = carcass aging with muscle tensioning; T3 = carcass aging with muscle tensioning and $CaCl_2$ marination; T4 = hot-boning breast collection; and T5 = hot-boning breast collection and $CaCl_2$ marination.

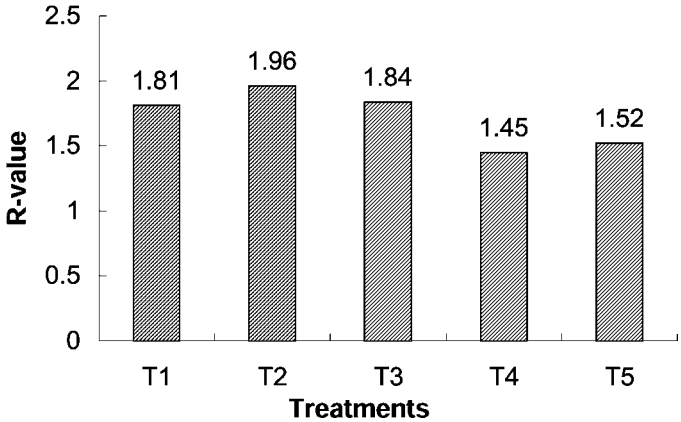

FIGURE 4. R-values of broiler breast meat collected after different treatments. T1 = Carcass aging; T2 = carcass aging with muscle tensioning; T3 = carcass aging with muscle tensioning and $CaCl_2$ marination; T4 = hot-boning breast collection; and T5 = hot-boning breast collection and $CaCl_2$ marination.

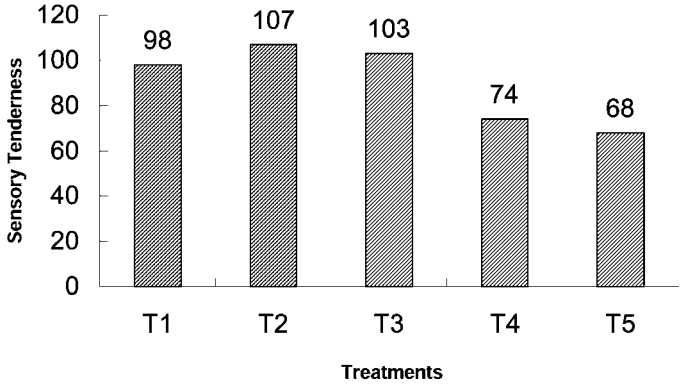

FIGURE 5. Totals for sensory tenderness scores attributed by panelists to broiler breast meat collected after different treatments. T1 = Carcass aging; T2 = carcass aging with muscle tensioning; T3 = carcass aging with muscle tensioning and $CaCl_2$ marination; T4 = hot-boning breast collection; and T5 = hot-boning breast collection and $CaCl_2$ marination.

monophosphate, and serves as a good monitor of ATP depletion (Thompson et al.,1987; Sams et al., 1989). In the present study, R-values were higher in carcasses aged for 24 h than in hot-boned carcasses, probably reflecting a more extensive degradation of ATP (Figure 4). Muscle tensioning and $CaCl_2$ treatment had no effect on R-values. Young and Lyon (1997), nonetheless, reported that $CaCl_2$ treatment increased R-values, indicating that rigor mortis was hastened by calcium treatments.

Sensory Tenderness

Aged meats subjected to muscle tensioning (T2 and T3) were more tender than those collected immediately after slaughter (hot-boned) and treated with $CaCl_2$ (T5), suggesting that muscle tensioning and boning time has important effect on the acceptance of cooked broiler meat (Figure 5). Lyon and Lyon (1990) reported that breasts deboned at 24 h postmortem had higher sensory responses for tenderness than breasts collected immediately after slaughter. $CaCl_2$ treatment had no effect on improving meat tenderness. Morgan et al. (1991) observed that beef treated with $CaCl_2$ had higher sensory responses than controls with no $CaCl_2$ treatment.

Conclusions

Breasts collected after 24 h had lower shear values than breasts collected immediately after slaughter. Carcass muscle tensioning during the aging period improved sensory tenderness of broiler breast meat. Marination in $CaCl_2$ decreased meat pH and increased cooking losses without affecting shear force. The results suggest that different times and temperatures should be further studied to assess the economic impact of this practice in tropical areas.

REFERENCES

Cason, J. A., C. E. Lyon, and C. M. Papa, 1997. Effect of muscle opposition during rigor on development of broiler breast meat tenderness. Poultry Sci. 76:785–787.

Honikel, K. O., C. Fischer, A. Hamid, and R. Hamm, 1981. Influence of postmortem changes in bovine muscle on the water holding capacity of beef. postmortem storage of muscle at 20°C. J. Food Sci. 46:1–6.

Janky, D. M., M. G. Dukes, and A. R. Sams, 1992. Research Note: The effects of postmortem muscle tensioning (muscle tensioning) on tenderness of early-harvested broiler breast meat. Poultry Sci. 71:574–576.

Lyon, C. E., and B. G. Lyon, 1990. The relationship of objective shear values and sensory tests to changes in tenderness of broiler breast meat. Poultry Sci. 69:1420–1427.

Lyon, C. E., B. G. Lyon, and J. A. Dikens, 1998. Effects of carcass stimulation, deboning time, and marination on color and texture of broiler breast meat. J. Appl. Poultry Res. 7:53–60.

Lyon, C. E., M. C. Robach, C. M. Papa, and R. L. Wilson, Jr., 1992. Research Note: Effects of muscle tensioning on the objective texture of commercially processed broiler breast meat. Poultry Sci. 71:1228–1231.

Morgan, J. B., R. K. Miller, F. M. Mendez, D. S. Hale, and J. W. Savell, 1991. Using calcium chloride injection to improve tenderness of beef from mature cows. J. Anim. Sci. 69:4469–4476.

Papa, C. M., and C. E. Lyon, 1989. Shortening of pectoralis muscle and meat tenderness of broiler chickens. Poultry Sci. 68:663–669.

Sams, A. R., D. M. Janky, and S. A. Woodward, 1989. Tenderness and R-value changes in early harvested broiler breast tissue following post-mortem electrical stimulation. Poultry Sci. 68:1232–1235.

Sams, A. R., D. M. Janky, and S. A. Woodward, 1990. Comparison of two shearing methods for objective tenderness evaluation and two sampling times for physical-characteristc analysis of early-harvest broiler breast meat. Poultry Sci. 69:348–353.

SAS Institute, 1996. SAS® User's Guide: Statistics. SAS Institute Inc., Cary, NC.

Snedecor, G. W., and W. G. Cochran, 1967. Statistical Methods 6th ed. The Iowa State University Press, Ames, IA.

Stone, H., J. L. Sidel, 1985. Sensory Evaluation Practices. Academic Press Inc., San Diego.

Thompson, L. D., D. M. Janky, and S. A. Woodward, 1987. Tenderness and physical characteristics of broiler breast fillets harvested at various times from post-mortem electrically stimulated carcasses. Poultry Sci. 66:1158–1167.

Veeramuthu, G. I., and Sams A. R., 1999. Postmortem pH, myofibrillar fragmentation, and calpain activity in *pectoralis* from electrically stimulated and muscle tensioned broiler carcasses. Poultry Sci. 78:272–276.

Young, L. L., J. M. Garcia, and C. M. Papa, 1991. Effect of divalent cations on biochemical and functional parameters of pre- and postrigor chicken breast fillets. Poultry Sci. 70:2354–2358.

Young, L. L., and C. E. Lyon, 1997. Effect of calcium marination on biochemical and textural properties of peri-rigor chicken breast meat. Poultry Sci. 76:197–201.