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Meat Quality Evaluation of Broiler Breast Fillets Affected by Aging Time and Marination

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Abstract: Poultry meat production in Argentina has experienced an important increase. Poultry processors have incorporated different strategies to reduce processing time and improve quality of breast fillets. The aim of the study was to evaluate the effect of deboning time and marination on meat quality of broiler breast fillets produced in Argentina. Three hundred sixty commercial 48 d old male broilers were aged for 0, 2, 4, 6, 8 or 24 h before deboning. After deboning pH and color were determined. The right fillet of each breast was immediately quick-frozen and the left fillet was marinated by injection and then quick-frozen. All breast fillets were stored when frozen for 60 d and then thawed for pH, color, Warner-Bratzler shear force and thawing loss determinations. pH measured at deboning decreased during the first 4 h of aging in not marinated fillets. Measures taken after frozen storage showed no changes in pH with aging time. Lightness measured at deboning increased with aging time. Shear values in both marinated and not marinated fillets decreased as from 6 h of aging. Furthermore, marinated treatment reduced shear values in all aging time.

Key words: Poultry breast fillet, aging, marination, meat quality

INTRODUCTION

Poultry meat quality is defined by a combination of many ante-mortem and post-mortem factors (Lyon *et al*., 2004). Carcass composition and quality may change in relationship with genetic, ambient, nutritional factors and slaughter conditions (Xiong *et al*., 1993; Aberle *et al.*, 2001; Qiao *et al*., 2002; Lonergan *et al*., 2003).

In recent years, poultry meat production in Argentina has experienced an important increase. The goal of the poultry industry is to reach 2015 with an annual growth of 10% in exports and 1 kg per capita in domestic consumption (Merino-Soto, 2009). Poultry processors have incorporated different strategies such as reducing carcass aging time and/or marinating. Plant efficiency could be improved by shortening aging duration, thereby reducing carcass storage space, storage costs and time to fill customer orders (Northcutt *et al*., 2001). However, if meat is excised from carcasses before the rigor mortis resolution, muscle fibers will be contracted and the muscle shortened. Numerous studies have shown that early harvesting of breast fillets results in tough, unacceptable texture (Dawson *et al*., 1987). Aging of chicken carcasses before further processing has a strong influence on tenderness of deboned and frozen breast fillets. The moment of completion of rigor mortis seems to be crucial for prediction of breast fillets tenderness. If rigor mortis has not been completed, deboning and freezing may lead to severely increased toughness of meat (Thielke *et al*., 2005). Therefore, it has been recommended aging carcasses before deboning (Dawson *et al*., 1987; Thielke *et al*., 2005). Some researchers consider the aging previous to deboning the most important way to ensure breast meat tenderness without deteriorating other quality characteristics (Fletcher, 2002). Nevertheless there are significant differences in the minimum aging time in published reports. Young *et al*. (1999) found differences in Warner-Bratzler shear force up to 2 h of aging. Stewart *et al*. (1984), Lyon *et al*. (1985) and Northcutt *et al*. (2001) have suggested a minimum time of 4 h whereas Thielke *et al*. (2005) proposed at least 6 h.

Marination treatment has shown to improve meat tenderness in chicken meat (Alvarado and McKee, 2007). Nevertheless, the chemical state of miofibrilar proteins will determine the effectiveness of salts to improve meat characteristics (Camou and Sebranek, 1991). Bauermeister and McKee (2005) suggested that the use of marination could be an effective means of alleviating toughness associated with deboning fillets as early as 2 h post-mortem. Smith and Young (2007) found that phosphate significantly increased cook weight and cook yield while L* and a* values slightly but significantly decreased. Yoon (2002) treated chicken breasts with 10% trisodium phosphate and sodium tripolyphosphate (by immersion for 10 min), those solutions significantly reduced drip and cooking losses as well as minimized ice crystal formation and freeze-induced shrinkage of myofibrils. No significant texture

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toughening was observed in frozen chicken breasts regardless of treatments.

The objective of the present study was to evaluate the effect of aging time prior to deboning and marination on meat quality of broiler breast fillets produced in Argentina.

MATERIALS AND METHODS

Animals and experimental design: Three hundred sixty commercial 48 d old male broilers of similar live weights (2.8±0.2 kg) were slaughtered in an industrial poultry processing plant (three trials of 120 birds each). The birds were stunned (72 V for 8 s), exsanguinated (2 min), scalded (55°C for 2 min), automatically eviscerated, washed and chilled in ice water (1°C for 30 min) in an agitated chiller. After chilling, broiler front-halves were removed from the carcasses and aged for 0, 2, 4, 6, 8 or 24 h in refrigerated storage at 3±1°C. Aging started 1 h and 15 min postmortem. After each aging time, breasts were skinned and automatically deboned. Right fillets were individually quick-frozen (-30±2°C); left fillets were marinated by injection at 6% with a solution of 7% wt/vol (2/1 NaCl/sodium tripolyphosphate) and then individually quick-frozen. All breast fillets were frozen storage for 60 d and then thawed 24 h (at 3±1°C) for analytical determinations.

Analytical procedures: pH and color were determined in *Pectoralis major* muscle at two different stages: a) immediately after aging and deboning and b) after frozen storage and thawing, in both marinated and not marinated fillets (Fig. 1). pH was measured in triplicate using a pH meter with puncture electrode (Oakton, Singapore). Surface meat color was determined using a Minolta CR-300 (Minolta Camera Co. Osaka, Japan), D_{65} light source and observer 2°, in triplicate. Lightness L*, redness a* and yellowness b* (CIE, 1976) were evaluated.

Thawing loss of marinated and not marinated fillets was calculated as the difference between frozen weight and thawing weight fillet, expressed as a percentage of the initial sample weight (thaw loss % = [(Initial weight-thawed weight)/initial weight] x 100). For determination of Warner-Bratzler shear force (WB), fillets (marinated and not marinated, frozen storage and thawed) were individually cooked in plastic bags immersed in a 100°C water bath to an internal temperature of 71°C. Internal muscle temperature was monitored using a multiple temperature recorder (Yokogawa, model DX106-1-2, China). When samples reached an internal temperature of 71°C, the bags containing the cooked meat were immersed in 1±0.5°C water for 15 min to stop cooking. For shear analysis, fillets were held at 4°C for 24 h. Four 1.30-cm-diameter cores were removed from each fillet. Warner-Bratzler shear force (N) was determined using a texture analyzer (Stable Micro Systems TXT, UK) with a Warner-Bratzler cell (AMSA, 1995).

Statistical analysis: Data were analyzed using Statgraphics centurion XV (StatPoint Technologies, Inc., Warrenton, VA, USA) for two-way Analysis of Variance using aging time and marinating as main effects. Duncan's multiple range test was used to identify significant differences among treatments ($p<0.05$).

RESULTS AND DISCUSSION

After aging and deboning, in fillets

pH: After aging and deboning (before marination and/or quick-frozen) the pH of fillets decreased up to 4 h and then no significant change was observed (Table 1). Therefore, the beginning of the onset of rigor mortis could be earlier than 5 h and 15 min postmortem, under present study conditions. Thielke *et al*. (2005) reported a gradual decrease in breasts pH during the first 4.5 h of aging; further aging up to 24 h did not bring any significant change. These authors concluded that the beginning of the onset of rigor mortis was earlier than 6 h and 21 min postmortem. However Young *et al*. (1999) studied the pH of fillets from 0 to 6 h and reported a decrease in pH values between 0 and 2 h of aging without changes up to 6 h.

Color: Lightness increased with aging time (Table 1). The lowest L* value was observed at 0 h aging when pH was highest. In red meats Ledward *et al*. (1986) found that the difference in meat lightness could have been caused by the difference observed in pH since high pH meats tend to have a darker color. Indeed several studies have found a high significant correlation between pH and poultry meat lightness (Fletcher, 1999; Le Bihan-Duval *et al*., 2001; Teira *et al*., 2004).

The main color differences with aging time were observed in fillets aged 24 h before deboning with the highest lightness and the lowest a* and b* values. Similar L* and a* results were reported by Souza *et al*. (2005). Huezo *et al*. (2007) found an increased in L* and no changes in a* and b* values in fillets from 0-24 h postchill aging.

After frozen storage, in marinated and not marinated fillets

pH: Marinated treatment increased pH values in fillets aged 0 and 2 h with regard to not marinated fillets. No differences were found in remaining aging times (Table 2). Marinades containing polyphosphate that are applied before completion of the rigor process (within 2-4 h postmortem) tend to increase meat pH more than do similar marinades applied after completion of the rigor process (Young and Buhr, 2000). The magnitude of this effect is affected by rigor state (Young and Lyon, 1994; Young *et al*., 1999). According to Young and Lyon (1994) the pH of post-rigor muscle is less affected by phosphate treatment than high pH. Young *et al*. (2005) found a higher pH value with sodium tripolyphosphate

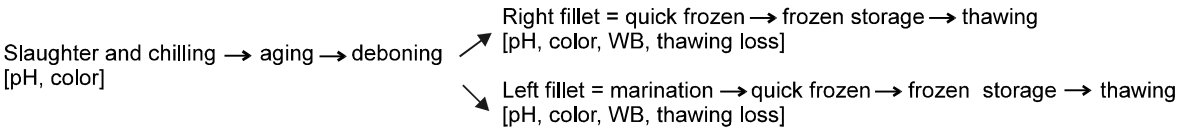

Fig. 1: Procedure and analytical determinations

Table 1: pH and color (L*, lightness; a*, redness; b*, yellowness) of chicken breast fillets deboned at different aging times (mean values±SD)

Aging time[A] (h)	pH	L*	a*	b*
0	6.09±0.19a	48.4±2.5a	3.2±0.6a	-2.7±1.0a
2	5.86±0.19b	51.1±2.3b	3.7±0.5b	-2.0±1.4ab
4	5.73±0.16c	51.5±2.6b	3.2±0.4a	-2.0±1.3ab
6	5.70±0.18c	51.5±1.7b	3.5±07ab	-1.5±1.5b
8	5.72±0.17c	52.7±1.8bc	3.3±0.5a	-1.0±1.5b
24	5.74±0.15bc	53.4±1.5c	1.6±0.5c	0.1±0.2c

[A]post mortem time plus 1 h and 15 min. Means within a column with different letters differ significantly ($p<0.05$)

and NaCl solution by tumbling than the control without sodium tripolyphosphate in fillets deboned immediately after chilling.

In the present study not marinated fillets pH at 0 and 2 h of aging and after deboning (Table 1) were higher than pH of the same fillets after frozen storage and thawing (Table 2). This is probably due to physicochemical processes that are taking place during thawing. According to Yu *et al*. (2005) when meat is stored frozen, glycolysis proceeds in the muscle. Most studies report the pH of the fillet at deboning time, although there is little information about pH values when the product is stored frozen before consumption. According to current results when fillets are kept in frozen storage and thawed, the final pH values are similar despite of the aging time before deboning.

Color: No significant differences were observed in L* values by marinated treatment. In not marinated fillets, changes in lightness were observed at 2 h of aging (Table 3). These results are different from those observed in fillets at deboning (Table 1). Significant differences in a* and b* values were observed with aging time and marinated treatment (Table 3) but they did not show a definite behaviour. Color values of poultry muscle are pH dependent (Young and Lyon, 1994) therefore alteration of color values by phosphate treatment should not be unexpected.

Souza *et al*. (2005) did not found color differences in fillets at different aging times when color measures were made at deboning and 24 h after chilling. Young *et al*. (1999) studied the color of cooked breast meat during 6 h aging. In this study, the addition of sodium tripolyphosphate by tumbling did not change color parameters significantly. Young *et al*. (2005) found similar L*, a* and lower b* values in marinated than not marinated fillets. Lyon *et al*. (1998) reported that marinated poultry muscles were less red (a*) and less yellow (b*) compared to not marinated meat. Smith and Young (2007) found a slightly but significant decreased in L* and a* values by phosphate tumbling. Bauermeister and McKee (2005) reported that lightness decreased in breast fillets by marination with salt and phosphate (injection and/or tumbling) at 2 and 4 h postmortem determined immediately after marination (without frozen).

Shear values: No differences were found in shear force of fillets aging 0, 2 and 4 h after deboning, these values decreased at 6 h and at 24 h of aging in both marinated and not marinated fillets (Table 2). Similar results were reported by Thielke *et al*. (2005) who suggest that aging chicken carcasses at least 6 h prior to deboning and freezing was necessary to obtain a tender product. Sams (1990) and Seabra *et al*. (2001) found that carcasses aging for 24 h produced meat with lower shear values than that from hot deboned. Papa and Lyon (1989) reported that breast muscles removed prior to the depletion of Adenosine Triphosphate (ATP) would result in tough cooked meat.

In the present study, marinated treatment showed significant differences with lower shear values (more tenderness) than not marinated fillets at all aging times studied. A decrease may be observed in shear force variability due to aging time and marinated treatment. Lyon *et al*. (1998) found a high WB shear values in fillets not marinated than marinated (7.6 vs 4.3 kg respectively). Bauermeister and McKee (2005) reported a reduction in shear values by injection with salt and phosphate. Saha *et al*. (2009) assessed consumer acceptance of marinated broiler breast fillets deboned pre (before 4 h postmortem) and post-rigor (greater than or equal 4 h postmortem). The results of Saha *et al*. (2009) indicate that marination of pre-rigor deboned meat is effective in producing products similar to marinated post-rigor deboned meat, suggesting its effectiveness in improving meat quality attributes of early deboned meat.

Other studies (Young *et al*., 1999) have concluded that breast meat from carcasses treated with sodium tripolyphosphate by tumbling at 0 h post chill (approximately 1 h postmortem) had 35% greater shear values than control meat without phosphate. However, sodium tripolyphosphate treatment had no effect on shear values if the treatment was applied 2 or more hours post chilling up to 6 h (Young *et al*., 1999). Similar

Table 2: pH, shear values and thawing loss of chicken breast fillets deboned at different aging times, marinated and not marinated after frozen storage (mean values±SD)

	pH			WB shear values (N)			Thawing loss (%)		
Aging time[A](h)	Not marinated	Marinated	p<0.05	Not marinated	Marinated	p<0.05	Not marinated	Marinated	p<0.05
0	5.67±0.20a	5.80±0.15a	*	37.7±10.8a	28.1±10.3a	*	3.1±1.1a	4.1±1.8a	NS
2	5.57±0.15a	5.78±0.17a	*	40.7±18.8a	23.3±9.1a	*	3.1±2.1a	3.3±1.6a	NS
4	5.68±0.23a	5.76±0.22a	NS	37.7±13.5a	25.9±9.8a	*	3.2±2.2a	3.1±2.2a	NS
6	5.72±0.14a	5.76±0.15a	NS	28.8±9.4b	19.6±6.8bc	*	4.2±2.2a	3.3±2.1a	NS
8	5.66±0.25a	5.68±0.14a	NS	28.7±11.3b	19.7±9.6bc	*	3.2±2.3a	4.4±2.8a	NS
24	5.67±0.13a	5.76±0.21a	NS	20.3±7.4c	16.5±6.8c	*	4.1±2.4a	4.1±2.2a	NS

[A]postmortem time plus 1 h and 15 min. Means within a column with different letters differ significantly (p<0.05). NS: Not Significant

Table 3: Color (L*, lightness; a*, redness; b*, yellowness) of chicken breast fillets deboned at different aging times, marinated and not marinated after frozen storage (mean values±SD)

	L*			a*			b*		
Aging time[A](h)	Not marinated	Marinated	p<0.05	Not marinated	Marinated	p<0.05	Not marinated	Marinated	p<0.05
0	46.6±1.5a	47.0±1.8a	NS	4.6±0.7a	4.0±0.7a	*	-2.0±1.3a	-2.3±1.0a	*
2	47.9±2.3b	48.3±1.7bc	NS	3.9±1.1b	4.5±1.1bc	*	-0.1±1.7b	-1.8±1.4ab	*
4	47.8±1.5b	48.1±1.7b	NS	4.6±0.8a	4.4±0.5abc	NS	-0.3±1.1b	-1.3±1.4bc	*
6	48.2±2.0b	48.5±1.8bc	NS	4.1±0.7b	4.5±0.7bc	NS	-0.1±1.2b	-1.0±1.3cd	*
8	48.8±1.4b	49.2±1.4c	NS	4.8±0.6a	4.3±0.9ac	NS	-0.5±1.3b	-1.3±1.4bc	*
24	48.5±1.7b	48.9±1.3bc	NS	4.6±0.7a	4.8±0.8b	NS	-0.4±1.3b	-0.3±1.4d	NS

[A]postmortem time plus 1 h and 15 min. Means within a column with different letters differ significantly (p< 0.05). NS: Not Significant

results were reported by Young and Lyon (1997) who found that immediately after chilling tripolyphosphate meat had 60% higher shear values than control meat. Nevertheless other researchers have concluded that polyphosphate treatment did not show any significant effect on shear values at 2 or 6 h post chill (Lyon and Lyon, 2000; Young and Buhr, 2000). These different results suggest that the ultimate quality of poultry meat could be affected by interactions between polyphosphates and processing parameters, such as stunning time or post-mortem time at which the polyphosphates were applied (Yoon, 2002).

Thawing loss: No significant differences were found in fillets by marinated treatment or aging time (Table 2). Thawing loss was about 3-4%. Galobart and Moran (2004) studied fillets obtained 24 h post-mortem, frozen storage in polyethylene bags (-20^{o}C, 5 mo) and thawed (4^{o}C, 24 h) and found a thawing loss of 7.7%. Other studies reported a loss of liquid of 0.8-1.7% during the thawing process (Shrestha *et al*., 2009). Frozen and thawed deboned or sliced poultry is more susceptible to higher thaw loss because of the greater surface area (Jeremiah, 1996; Hui, 2006). Drip loss may be controlled in such products by marination combined with tumbling or injection (Hui, 2006). In the present study marinated fillets did not show less thaw loss than not marinated fillets, although marinated fillets were injected at 6% and this brine was withheld by the meat.

Conclusion: Measured at deboning, pH decreased during the first 4 h of aging (not marinated fillets). If measures were taken after frozen storage, no changes in pH with aging time would be observed in both marinated and not marinated fillets. Lightness measured at deboning increased with aging time (not marinated fillets). Marinated treatment or aging time did not change thawing loss in the present conditions. Shear values in both marinated and not marinated fillets decreased as from 6 h of aging. Marinated treatment reduced shear values in all aging times studied. Therefore, the tenderness of fillets is improved with a minimum aging time of 6 h before deboning. This is enhanced when the product is marinated.

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