

ISSN 1682-8356
ansinet.org/ijps



INTERNATIONAL JOURNAL OF
POULTRY SCIENCE

ANSI*net*

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

Effects of Pre-Evisceration Electrical Stimulation and Polyphosphate Marination on Color and Texture of Early Harvested Chicken Broiler Breast Fillets

L.L. Young¹, D.P. Smith¹, J.A. Cason¹ and J.M. Walker²

¹Richard B. Russell Agricultural Research Center, ARS, USDA, P. O. Box 5677, Athens, GA USA 30604

²Stork-Gamco, Inc., Gainesville, GA USA 30503

E-mail: lyoung@saa.ars.usda.gov

Abstract: Early harvested broiler breast fillets from electrically stimulated and non-stimulated carcasses were marinated in either saline or saline containing sodium tripolyphosphate to determine whether the stimulation and phosphate interact in such a way as to affect texture or color of non-aged breast fillets. Stimulated carcasses produced fillets with lower pre-marination pH (6.1 ± 0.1 versus 6.5 ± 0.1) and shear values (6.4 ± 0.3 kg versus 15.5 ± 0.3 kg) than unstimulated carcasses. Polyphosphate increased shear values of fillets from unstimulated by almost 1 kg, but not of those from stimulated carcasses. No other stimulation by polyphosphate interactions that affect texture or color of the fillets were detected.

Key words: Electrical stimulation, polyphosphate, poultry, meat, color, texture

Introduction

Trends in poultry marketing in the developed world are towards partially prepared and ready-to-eat products. Such products tend to exhibit excessive dryness, so food processors often add ingredients such as sodium tripolyphosphate (STPP) to help the products retain moisture during cooking (Miller *et al.*, 1968; Young and Lyon, 1994; Young *et al.*, 1987, 1992). STPP can also affect other quality attributes as well such as color (Young and Lyon, 1994, 1997; Young *et al.*, 1999) and texture (Young *et al.*, 1987). Even though these effects of STPP are well known, they can be altered if the additive is used in combination with other factors. Young and Lyon (1994) demonstrated that effects of STPP on meat color are dependent on state of rigor. Phosphate-treated turkey breast fillets were redder than non-phosphate-treated fillets if the STPP treatment was applied immediately post mortem, but the phosphate had no effect on color of fillets aged for 24 h prior to phosphate treatment, perhaps reflecting pH sensitivity of muscle pigments. Young and Lyon (1997) also demonstrated very high shear values (an indicator of toughness) in meat from chicken broiler breast quarters that were treated with STPP immediately post mortem. If the quarters were aged for as little as 120 min prior to phosphate treatment, the toughening effect was avoided. Effects of STPP on color were unaffected by aging. In a follow up study, Young *et al.* (1999) showed that the toughening effect of STPP on non-aged meat can be avoided if the carcass is subjected to electrical stimulation (ES) during slaughter. Even though the toughening and color altering effects of STPP on intact fore quarters and the ability of ES to eliminate those effects is known, combined effects of ES and STPP on quality of boneless breast fillets has not been evaluated. The objective of this study was determine whether or not

ES and STPP interact in such a way as to affect texture or color of non-aged boneless breast fillets.

Materials and Methods

Chickens and Sample Preparation: Three replicates of thirty-two 53-day old commercially reared broilers (ninety-six birds in all) were obtained from the holding yard of a local commercial poultry-processing establishment. They were transported 32 km to the pilot processing facility where they were immediately slaughtered using conventional US techniques. Half the carcasses to be stimulated (48) were removed from the line prior to evisceration in groups of four and hung by the feet on the grounded shackles of a prototype commercial-style stimulator with the breast skin in the area of the sternum contacting a charged stainless steel plate. Birds were stimulated at a controlled, pulsed potential difference of 220 volts (alternating current), 0.5 s on and 1 s off for 90 s. The remaining carcasses were held in a similar environment, but were not stimulated. Each carcass was manually eviscerated, chilled in ice water for 30 min, drained for 10 min and then both *Pectoralis major* muscles were excised (60 min post mortem) and subjected to pre-marination color value and pH analysis. Left muscles were immediately marinated in a commercial vacuum tumbler for 20 min in an aqueous solution containing 10% (wt/vol) NaCl and 4% (wt/vol) STPP. Right muscles were marinated similarly, but the marinade contained no STPP. Tumbling conditions were 440 mm Hg vacuum, speed setting 40% (~14 revolutions per min) and temperature of the marinade 4°C. Marination was carried out at 4°C ambient temperature. After marination, the posterior end of each muscle was sampled for pH measurement, evaluated for post-marination color value analysis, vacuum sealed in a cooking bag, and cooked by

Table 1: Effects of electrical stimulation and polyphosphates on pH and cooked shear values of marinated breast fillets

Electrical Stimulation	Marinade	N	Marinated pH	Shear Value (kg)
Non-Stimulated	No STPP	48	6.20 ^b	14.6 ^b
	STPP	48	6.35 ^a	16.5 ^a
Stimulated	No STPP	48	6.14 ^c	6.7 ^c
	STPP	48	6.22 ^b	6.4 ^c
SEM	192	36.9	0.002	0.32

^{a,b,c}Means in the same column that share no common superscripts differ significantly (P = 0.05).

Table 2: Effect of electrical stimulation on CIE (1978) color values of raw, marinated and cooked chicken breast fillets

Electrical Treatment	N	Pre-Marination Color Values			Post-Marination Color Values			Cooked Color Values		
		L*	a*	b*	L*	a*	b*	L*	a*	b*
Non-Stimulated	64	45.8 ^{a,y}	2.47 ^x	5.46 ^y	45.6 ^y	2.16 ^x	4.60 ^{a,z}	78.9 ^{b,x}	1.89 ^y	15.76 ^{a,x}
Stimulated	64	44.2 ^{b,y}	2.42 ^x	4.74 ^y	44.0 ^y	2.30 ^x	3.48 ^{b,z}	79.3 ^{a,x}	1.86 ^y	14.79 ^{b,x}
SEM	128	0.024	0.008	0.020	0.026	0.008	0.022	0.009	0.007	0.013

^{a,b}Means in the same column that share no common superscripts differ significantly (P = 0.05).

^{x,y,z}Means in the same color values in the same row that share no common superscripts differ significantly (P = 0.05).

immersion for 20 min in a steam-heated temperature-controlled 80°C water bath. Final endpoint temperature averaged 80°C as measured on duplicate muscles immediately after cooking. The fillets were removed from the cooking bags immediately after cooking, allowed to drain for 30 min, covered with aluminum foil and stored over night in a 4°C cold room. The next day, fillets were tempered to room temperature and evaluated for color values and objective texture.

Meat pH: pH was evaluated using the iodoacetate method of Jaecocke (1977).

Color: Commission International D'Eclairage (CIE, 1978) L*, a* and b* color values were evaluated in triplicate on the central area of each fillet's ventral surface with a colorimeter. The three values were averaged as the values for each fillet.

Objective texture: Duplicate 1.9 cm wide by 1.9 cm thick strips were cut from the center of each fillet in parallel with muscle fibers. Each strip was sheared once using a Warner-Bratzler shear device and the values recorded in kg. Values from the duplicate shears were averaged as the shear value of the fillet.

Statistical analysis: Data were analyzed by ANOVA using replicates, ES/no ES and STPP/no STPP treatments as fixed main effects and testing main effects and interactions for statistical significance (P = 0.05) using the error MS. Except in cases of significant interactions, pooled least squares means of the main effects were calculated and compared using Student's t-test (P = 0.05). In cases of statically significant interactions, least squares means of all levels of the interacting main effects were calculated and compared

using Student's t-test (P = 0.05).

Results and Discussion

ES produced an immediate drop in muscle pre-marination pH from a mean±SEM of 6.5±0.1 for non-stimulated muscles to 6.1±0.1 for stimulated muscles, but phosphate marination mitigated this effect somewhat (Table 1). Nevertheless, regardless of marinade treatment, pH values of muscles from stimulated carcasses were always lower than those from non-stimulated carcasses, reflecting the depletion of ATP and accumulation of lactate affected by ES (Maki and Froning, 1987; Froning and Uijttenboogaart, 1988; Lyon *et al.* 1989; Young *et al.*, 1999). Li *et al.* (1993) observed that in most cases, muscle pH is an indicator of development of rigor mortis and is correlated with decrease of shear values of poultry meat. The overall 58% decrease in shear values affected by ES reflects that correlation. Polyphosphates were shown to increase muscle pH by Young *et al.* (1992) and Young and Buhr (2000), but this same group also showed that the magnitude of that effect is affected by rigor state (Young and Lyon, 1994; Young *et al.*, 1999;). The pH of post rigor muscle is less affected by phosphate treatment than is that of high pH (pre- or peri-rigor) muscle. In previous studies (Young *et al.*, 1999), the difference in phosphate treatment resulted in much greater shear values for pre- and peri-rigor meat than for post-rigor meat. If pH of unaged muscle was artificially reduced by ES, shear values of phosphate-treated muscle were much lower than non-stimulated phosphate-treated muscle. In the present study, shear values of phosphate-treated fillets from non-stimulated carcasses were significantly greater than those of similar fillets that received no STPP treatment. Although rigorous comparisons between the two studies are not

possible, the difference was greater in the former studies than in the present, perhaps reflecting somewhat different stimulating conditions. In the earlier work, current flowed between head and feet during exsanguination, but in the present study, current flowed between breast and feet and was applied after feather removal and before evisceration.

Effects of ES and polyphosphate marination on color values of raw and cooked fillets are shown in Table 2. ES affected a significant but small decrease in lightness (L^*) in both non-marinated and marinated fillets. In the previous study (Young *et al.*, 1999), cooked fillets from non-stimulated carcasses were lighter (greater L^*) than those from stimulated carcasses, but in that study, marination was carried out at 0 to 6 h post-mortem whereas marination in the present study was carried out at 60 min post-mortem. Muscle pH differences between 60 min and up to 6 h aged meat could account at least in part for the varying results (Young and Lyon, 1994). Polyphosphate marination reduced the yellowness (b^*) of fillets from both non-stimulated and stimulated carcasses, but otherwise did not affect color values. STPP increased fillet pH, especially in fillets from non-stimulated carcasses. STPP marination is more effective in increasing muscle pH of unaged muscle than aged muscle due in part to the buffering effect of lactate. Because color values of poultry muscle are pH dependent (Young and Lyon, 1994), alteration of color values by phosphate treatment should not be unexpected. In the previous study by Young and Lyon (1994), a^* (red) values increased during phosphate marination, but that study involved turkey breast meat, a more highly pigmented muscle than chicken broiler breast meat.

Cooking the marinated fillets lightened (increased L^*) the fillets and made them less red (reduced a^*) and more yellow (greater b^*). The only ES-mediated differences in color values that remained after cooking was a small but significant increase in yellowness.

Previous work identified potential toughening problems if bone-in poultry meat is prematurely marinated with polyphosphates (Young *et al.*, 1987) and demonstrated that those problems were alleviated with ES (Young *et al.*, 1999). The present study indicates that these problems may not be inevitable or may be of a lesser magnitude than indicated previously. Rigorous comparisons are not possible between this study which used breast to feet stimulation of defeathered carcasses instead of head to feet stimulation of feathered carcasses as in the previous studies, but potential quality problems identified previously may be avoidable by modifying ES methodology. In any case, the data illustrate the importance of careful timing of treatments such as ES and marination.

References

- CIE, 1978. International Commission on Illumination, Recommendations on Uniform Color Spaces, Color-Difference Equations, Psychometric Color Terms. Supplement No. 2 to CIE publication No. 14 (E-1.3.1) 1871. Bureau Central de la CIE, Paris, France.
- Froning, G.W. and T.G. Uijttenboogaart, 1988. Effect of postmortem electrical stimulation on color, texture, pH, and cooking losses of hot and cold deboned chicken broiler breast meat. *Poult. Sci.*, 67: 1536-1544.
- Jaecocke, R.E., 1977. Continuous measurement of the pH of beef muscle in intact beef carcasses. *J. Food Tec.* 12: 375-386.
- Li, Y., J. Seibenmorgan and C.L. Griffis, 1993. Electrical stimulation in poultry: A review and evaluation. *Poult. Sci.*, 72: 7-22.
- Lyon, C.E., C.E. Davis, J.A. Dickens, C.M. Papa and J.O. Reagan, 1989. Effects of electrical stimulation on the postmortem biochemical changes and texture of broiler pectoralis muscle. *Poult. Sci.*, 68: 249-257.
- Maki, A. and G.W. Froning, 1987. Effect of postmortem electrical stimulation on quality of turkey meat. *Poult. Sci.*, 66: 1155-1157.
- Miller, W.O., R.L. Saffle and S.B. Zirkle, 1968. Factors which influence water-holding capacity of various types of meat. *Food Tec.*, 22: 1139-1142.
- Young, L.L. and R.J. Buhr, 2000. Effect of electrical stimulation and polyphosphate marination on drip from early-harvested, individually quick-frozen chicken breast fillets. *Poult. Sci.*, 79: 925-927.
- Young, L.L., R.J. Buhr and C.E. Lyon, 1999. Effect of polyphosphate treatment and electrical stimulation on postchill changes in quality of broiler breast meat. *Poult. Sci.*, 78: 267-271.
- Young, L.L. and C.E. Lyon, 1994. Effects of rigor state and addition of polyphosphates on the color of cooked turkey meat. *Poult. Sci.*, 73: 1149-1152.
- Young, L.L. and C.E. Lyon, 1997. Effect of calcium marination on biochemical and textural properties of peri-rigor chicken meat. *Poult. Sci.*, 76: 197-201.
- Young, L.L., C.E. Lyon, G.K. Searcy and R.L. Wilson, 1987. Influence of sodium tripolyphosphate and sodium chloride on moisture-retention and textural characteristics of chicken breast meat patties. *J. Food Sci.*, 52: 571-574.
- Young, L.L., C.M. Papa, C.E. Lyon and R.L. Wilson, 1992. Moisture retention and textural properties of ground chicken meat as affected by sodium tripolyphosphate, ionic strength and pH. *J. Food Sci.*, 57: 1291-1293.