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Effects of Intact Carcass Electrical Stimulation on Moisture Retention Characteristics of Polyphosphate-Treated Non-Aged Boneless Broiler Breast Fillets

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Abstract: The objective of this study was to evaluate combined effects of whole carcass electrical stimulation and polyphosphates on moisture absorption and retention by marinated non-aged boneless chicken breast fillets. Breast fillets were harvested from electrically stimulated and non-stimulated carcasses immediately after chilling. Half were immediately marinated in saline solution and half in a similar solution containing sodium tripolyphosphate. Muscle pH before and after marination, marinade absorption and cooking loss were recorded. Electrical stimulation immediately depressed muscle pH, but polyphosphate marination mitigated that trend somewhat. Electrical stimulation improved marinade absorption (10.6±0.3% verses 8.8±0.3%) but did not affect cooking loss. Polyphosphates did not affect marinade absorption, but significantly reduced cooking losses (17.3±0.4% verses 14.1±0.4%). No marinade by electrical treatment interactions affecting moisture absorption or retention by the fillets were detected.

Key words: Electrical stimulation, marinade, poultry, polyphosphate, moisture

Introduction

In the past thirty years, marketing of poultry in much of the developed world has shifted from mostly intact ready-to-eat carcasses to largely parts or boneless fillets. This change has shortened the time between slaughter and cut up or deboning (second processing), so in many poultry slaughter plants carcasses are stored either under refrigeration or on ice for up to 8 h after chilling. This practice ensures depletion of muscle ATP prior to removing the breast muscles for cut up or further processing. Failure to include this "aging" or "conditioning" step can lead to consumer complaints of excessively tough meat (deFremery and Lineweaver, 1962; Stewart *et al*., 1984; Lyon *et al*., 1985). Ageing is not an inexpensive practice, however, because it requires additional storage space, refrigeration capacity, equipment and personnel. Moreover, the extra handling and storage increase opportunities for bacterial contamination and growth. Consequently, some processing plant operators are installing equipment and designing procedures that hasten depletion of muscle ATP thus reducing or eliminating the need for ageing. One such procedure that is gaining popularity in some processing plants is pulsed electrical stimulation (ES). This procedure involves subjecting the intact carcasses to pulsed electric current either during bleeding or immediately prior to evisceration. Repeated contraction of the breast muscles evoked by electric current depletes their stores of ATP thus eliminating the potential for muscle contraction after excision that can lead to toughness (Froning and Uijttenboogaart, 1988; Li *et al*., 1993; Locker, 1960; Lyon *et al*., 1989; Maki and Froning, 1987). Variations of this practice such as combining ES with abbreviated aging at non-refrigeration temperatures (Clatfelter and Webb, 1987; Sams, 1990), pre-chill muscle tensioning (Birkhold and Sams, 1993; Lyon and Dickens, 1993) and post-excision muscle clamping to prevent shortening (Cason *et al*., 2002) have been developed experimentally, but have received little if any commercial application.

Another marketing change has been towards partially prepared or cooked products. Such products can be excessively dry, so food manufacturers often include moisture retention aids such as sodium tripolyphosphate (STPP) in product formulations. STPP reduces exudate production in raw products, reduces cooking losses and improves juiciness (Farr and May, 1970; Mahon, 1962; Trout and Schmidt, 1984). Young *et al*. (1992) showed that effects of STPP on moisture-retaining properties of poultry meat resulted primarily from the salt's effects on ionic strength of the fluids in the meat, but pH affected efficacy of the STPP. Thus, one can hypothesize that if pH of non-aged muscle is reduced via ES, efficacy of STPP in controlling moisture losses during cooking might be affected. The objective of this study was to determine whether ES reduces pH of non-aged muscle sufficiently to alter efficacy of STPP as a moisture binding aid.

Materials and Methods

Sampling: Ninety-six fifty-three-d-old broilers (three replicates of 32 birds each) were procured from the

Table 1: Effect of whole carcass electrical stimulation on pH and moisture absorption and retention by non-aged polyphosphate-marinated chicken breast fillets

Electrical Treatment	N	Marinade	Marinated pH	Marinade Absorption (%)	Cooking Loss(%)
Non-Stimulated	48	No STPP	6.2[b]	8.7[b]	17.4[a]
	48	STPP	6.4[a]	8.9[b]	14.3[b]
Stimulated	48	No STPP	6.0[c]	10.1[a]	17.1[a]
	48	STPP	6.2[b]	11.9[a]	13.9[b]
SEM	192		0.002	0.25	0.35

[a,b]Values in the same column that share no superscripts differ significantly (P = 0.05).

holding shed of a commercial poultry processing company. They were transported 32 km to a pilot processing facility where they were slaughtered using conventional US techniques including mechanical killing, electrical stunning (15 V direct current, 12 s), immersion scalding (54°C, 120 s), mechanical picking, manual evisceration, manual inside and outside washing. Immediately after defeathering birds were removed from the processing line in groups of four and hung by the feet from grounded shackles with the ventral part of the breast adjacent to the sternum touching a charged steel plate. ES was carried out with pulsed current (220 V alternating current for 90 s, 0.5 s on followed by 1 s off). Non-stimulated birds were held in a similar atmosphere and time, but were not stimulated. Birds were manually eviscerated and then chilled in ice water. Chilling was carried out in a prototype paddle-type ice water immersion chiller (3°C), and was initiated at 30 min post-mortem and completed at 60 min post-mortem. After chilling, left and right *Pectoralis major* muscles were manually harvested. The posterior tip of each fillet was sampled for pre-marination pH evaluation, and then each muscle was weighed (pre-marination weight) and prepared for marination and cooking.

Marination and Cooking: At 1 h post-mortem, left pectoralis muscles were marinated for 20 min with a vacuum tumbler in a pre-chilled (4°C) aqueous solution containing 10% (wt/vol) NaCl and 4% (wt/vol) STPP. Marination conditions were 440 mm vacuum, speed setting 40% and ambient temperature 4°C. Right muscles were marinated similarly, but the marinade contained no STPP. Each marinated fillet was weighed (marinated weight), sampled as before for post-marination pH evaluation, weighed again (post-sampling weight), vacuum sealed in a cooking bag and cooked by immersion for 20 min in a steam-heated temperature-controlled 85°C water bath. Final endpoint temperature averaged 80°C as measured on duplicate muscles immediately after cooking. Fillets were allowed to drain for 30 min and weighed (Cooked Weight).

Muscle pH: pH of each muscle before and after marination was determined by the iodoacetate method as described by Jaecocke (1977).

Cooking loss and retention: Marinade absorption was evaluated as,
Absorption = 100 X (marinated weight – pre-marination weight) / pre-marination weight.
Cooking loss was evaluated as,
Cooking Loss = 100 X (post-sampling weight - cooked weight) / post-sampling weight.

Statistical analysis: Data were analyzed by ANOVA using replicates, electrical treatment and marinades as 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 square means of main effects were compared using Student's t - test (P = 0.05). In cases of significant interactions, least square means of all levels of interacting main effects were compared using Student's t - test (P = 0.05).

Results and Discussion

ES reduced muscle pH prior to marination from a mean of 6.5 for unstimulated muscles to 6.1 for muscles that received stimulation. Overall SEM was 0.01. ES increased marinade absorption from 8.8%±0.25 to 11.0% ± 0.25. Even though STPP marination increased pH of both stimulated and non-stimulated muscles, marinade absorption by fillets was not affected by marinade composition regardless of electrical treatment (Table 1). Other reports indicate that STPP treatment can increase marinade absorption (Mahon, 1962; Young and Lyon, 1986; Young and Buhr, 2000); however, these studies were conducted using aged and sometimes intact (bone in) parts, so it seems possible that treatment of fillets at 1 h post-mortem can account for the disagreement.
Cooking losses of fillets from stimulated and non-stimulated carcasses were equivalent. Overall average was 15.7%. Regardless of electrical treatment, STPP-treated fillets suffered lower cooking losses than did fillets that received no phosphate treatment (17.2% verses 14.1%). It appears that under the conditions of this study, ES and STPP marination function independently such that ES promotes marinade

absorption and STPP marination improves moisture retention during cooking; however, efficacy of each treatment is unaffected by the other.

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