ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF

POULTRY SCIENCE

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International Journal of Poultry Science 10 (10): 757-759, 2011
ISSN 1682-8356

Effect of Ultrasonic Marination on Broiler Breast Meat Quality and *Salmonella* Contamination

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Abstract: Two experiments were conducted to determine the effect of ultrasonic or static marination on meat quality measures (marination uptake, drip loss cooked yield and texture) and reduction of *Salmonella* and *Escherichia coli*. In experiment one, twelve butterfly fillets per each of two trials (n = 24) were collected from a commercial processing plant and trimmed of connective or fat tissue, then cut into paired fillets. One fillet from each pair was assigned to marination either with ultrasonication or without (static) for 20 min in a solution containing 91% water, 6% NaCl and 3% Sodium Tripolyphosphate (STP). Fillets were weighed, held for 18 h, cooked and analyzed for texture using Allo-Kramer shear. Sonication resulted in lower uptake (2.6%), less drip loss (1.1%) and lower cooked yield (84.3%) than static marination (4.8, 2.2 and 88.7%, respectively); there was no difference in shear due to marination method (3.4 vs. 3.7 kg/g). In experiment two, 4 trials were conducted to determine the effect of marination method on numbers of *Salmonella* and *Escherichia* (*E.*) *coli*. In each trial, two whole boneless (butterfly) skinless broiler breasts were obtained from a retail store and split into paired fillets (n = 8). Ten min prior to marination fillets were inoculated with 1.0 ml of a culture containing nalidixic acid-resistant strains of *Salmonella* (mean count of 7.1 $\log_{10}$) and *E. coli* (mean count of 6.1 $\log_{10}$). After marination fillets were sampled for bacterial enumeration. There were no significant ($p<0.05$) differences due to ultrasonication for either *Salmonella* (mean count 4.6 $\log_{10}$ CFU) or *E. coli* (mean count of 2.8 $\log_{10}$ CFU).

Key words: Ultrasonic marination, broiler meat texture, *Salmonella*, *E. coli*

INTRODUCTION

Marination has been used for many years and is now used extensively on processed meats and now is used on nearly half of all poultry meat produced in the US as reported by Smith and Acton (2010). Many techniques have been used for applying marinades to pultry meat. Commercially, poultry marination is accomplished by vacuum tumbling or injection. The simplest method of marination is static soaking, which has been used for poultry meat marination (Froning, 1965; Oblnger *et al*., 1976). Marination typically improves meat quality, but may also benefit meat safety by reducing numbers of bacteria and pathogens on meat (Alvarado and McKee, 2007).

Sonication, or the use of ultrasonic waves, has been used in a variety of applications, from medical to chemical processing fields. Sonication has also been used for food processing. A specific include reducing bacteria in foodborne pathogens (Piyasena *et al*., 2003). Although sonication may reduce bacteria, several researchers reported more success in reducing food bacteria by combining the sonic treatment with other methods of pathogen reduction, including ozone, antimicrobial chemicals, heat, or pressure (Burleson *et al*., 1975; Manas *et al*., 2000; Scouten and Beuchat, 2002; Cabeza *et al*., 2004; Wong *et al*., 2008).

Attempts to improve meat tenderness using sonication have been reported. Lower intensity ultrasonication was not effective in improving beef tenderness (Lyng *et al*., 1997) but higher intensity sonication did improve beef tenderness (Jayasooriya *et al*., 2007). Prior research has been conducted on combining sonication and marination together to both improve marination and to reduce bacteria on meat. Higher intensity sonication improved marination uptake of pork meat while lower intensity had no effect (Carcel *et al*., 2007). Combination treatments of sonication and marination reduced bacterial counts on pork muscle (Birk and Knochel, 2009).

Sonication, especially in combination with other treatments, may be useful in improving meat quality and safety. The objective of this study was to determine the effect of combining sonication and phosphate marination on 1) broiler breast meat marination and quality and 2) numbers of bacteria inoculated onto breast meat.

MATERIALS AND METHODS

Experiment 1: Twelve boneless, skinless butterfly broiler breasts were collected from a commercial processing plant and trimmed of connective or fat tissue (n = 24). Butterflies were cut into two fillets and one fillet of the pair was marinated for 20 min in a Branson ultrasonic cleaner (Model B-22-4, Branson Ultrasonics Corp., Danbury, CT) while the other fillet was marinated by static soaking for 2 h. The marination solution was composed of 91% water, 6% salt and 3% sodium tripolyphosphate (STP NEW, BK Giulini Corp., Simi

Valley, CA, 93063). Fillets were held 18 h to determine drip loss and then cooked in an electric oven to an internal temperature of 80°C. Marination pickup, drip loss and cook yield percentages were determined. The following calculations were used: Marination pickup = (marinated weight - raw weight)/raw weight x 100; drip loss = (marinated weight - aged weight)/marinated weight x 100 and cooked yield = cooked weight/raw weight x 100.

Fillet texture was measured by removing a 5 x 5 cm section from each fillet and measuring shear force (kg shear/g sample) in an Allo-Kramer (AK) 10 blade shear cell attached to an Instron Univeral Testing Machine. Crosshead speed was 100 mm/min and load cell was 20 kg. Samples were sheared with descending blades perpendicular to muscle fibers.

Data were analyzed by SAS ANOVA procedures (SAS, 2004). No significant ($p<0.05$) interactions were observed between trial and marination treatment so means were pooled. Treatment means were tested for significance ($p<0.05$) using the SAS paired t test.

Experiment 2: In each of four trials, two boneless, skinless butterfly broiler breasts were obtained from a retail store and split into two paired fillets (n = 8). One fillet from each pair was assigned to marination for 20 min either in an ultrasonic bath (as per Experiment 1) or by static soaking. The marination solution contained 91% water, 4.5% sodium chloride and 4.5% sodium tripolyphosphate. Ten minutes prior to marination, fillets were inoculated by placing 0.5 ml of the inoculants on one side for 5 min, then another 0.5 ml for 5 min on the other side. The inoculants contained nalidixic acid-resistant strains of *Salmonella typhimurium*, *heidelberg*, *montevideo* and *enteritidis* (mean count of 7.1 $\log_{10}$) and an *E. coli* strain (mean count of 6.1 $\log_{10}$). The bacteria were grown for 18 h at 37°C in Brain Heart Infusion broth and 1.0 ml of each culture was combined for the inoculation solution. After marination fillets were shaken for 1 min in a 50 ml rinse of 1% Buffered Peptone Water (BPW). Serial dilutions were plated onto Brilliant Green Agar (BGA) with sulfapyridine with 200 ppm nalidixic acid and incubated at 37°C for 24 h and onto *E. coli*/coliform Petrifilm and incubated at 35°C for 24 h. Marination solutions were also sampled after fillets were removed by removing 1.0 ml for serial dilution and plating.

Data were analyzed by SAS ANOVA procedures (SAS, 2004). Numbers of bacteria were converted to $\log_{10}$ CFU per ml prior to analysis. Means were pooled across trials as no significant ($p<0.05$) interactions were observed. Means were tested for significance ($p<0.05$) using the SAS paired t test.

RESULTS AND DISCUSSION

Experiment 1: Meat quality results are shown in Table 1. Marination pickup was significantly ($p<0.05$) lower for sonic than static marination (2.6 vs. 4.8%, respectively). Sonic marination produced lower drip loss than static (1.1 vs. 2.2%, respectively). Lower cook yield was observed with sonic marination (84.3) than with static marination (88.7%). There was no difference in texture due to marination method as measured by AK shear; sonic samples averaged 3.4 kg/g and static samples averaged 3.7 kg/g shear. Sonic marination did not improve marination pickup, cook yield, or AK shear compared to the static (control) method. The lower drip loss for sonicated samples was likely due to the much lower percentage of marinade uptake.

Table 1: Marination and meat quality measures (marination uptake, drip loss, cooked yield and AK shear) of broiler breast meat marinated by sonic or static methods (n = 24)

Treatment	Marination (%)	Drip loss (%)	Cooked yield (%)	AK shear (kg/g)
Sonic	2.6[b]	1.1[b]	84.3[b]	3.4
Static	4.8[a]	2.2[a]	88.7[a]	3.7

[a,b]Means in columns without common superscripts differ significantly ($p<0.05$)

The use of sonication for improving marination performance in meat has been reported (Carcel *et al*., 2007). Lower intensity ultrasound had no effect on meat mariantion, but higher intensity ultrasound improved marinaton of pork meat. The ultrasonic bath used in the current study had relatively low intensity, so lack of performance was likely due to the lower capability of the bath. Meat tenderness is similarly affected, as lower intensity water baths did not improve beef muscle tenderness (Lyng *et al*., 1997), but much higher power and intensity ultrasound did increase beef tenderness (Jayasooriya *et al*., 2007).

Experiment 2: As shown in Table 2, there were no significant ($p<0.05$) differences due to sonic vs. static marination treatment for *Salmonella* (mean log counts of 4.6 vs. 4.6, respectively). There was also no difference in log counts of *E. coli* (log 2.8 vs. 2.7, respectively).

A previous report describing the use of an ultrasonic bath on broiler drumsticks found no reduction of aerobic bacteria (Sams and Feria, 1991). Sonication alone resulted in no decrease of *Campylobacter jejuni* and limited reduction of *Listeria monocytogenes* on pork meat; however, combining sonication with red wine marination resulted in significant reductions of both pathogens (Birk and Knochel, 2009). Because wine has antimicrobial properties and other previous reports have shown combining sonication with other methods provided better results, lack of bacterial reductions in the current student may have been improved with use of an antimicrobial marinade instead of the phosphate solution.

Applying sonication during marination of broiler breast fillets is this experiment was not effective for improving

Table 2: Numbers of *Salmonella* and *Escherichia (E.) coli* (log_{10} cfu/ml) recovered from broiler breast fillets inoculated with *Salmonella* and *E. coli* prior to marination by sonic or static methods (n = 8)

	Salmonella	*E. coli*
	---------- (log_{10} cfu/ml) ----------	
Sonic	4.6	2.8
Static	4.6	2.7

marination uptake or retention, cooked yield or shear of poultry meat. Sonication also was not effective in reducing numbers of inoculated *Salmonella* or *E. coli*. The low power of the ultrasonic bath used and non-antimicrobial marinade solution were likely responsible for the findings. Further study with a higher intensity ultrasonic bath is indicated based on results from recent prior studies.

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