Utilizing marination and vacuum tumbling techniques to optimize tenderness of breast fillets deboned early post-mortem

L.J. BAUERMEISTER and S.R. MCKEE*

Poultry Products Safety and Quality Program, 201 Poultry Science Building, Auburn University, AL 36849 USA
*mckeesr@auburn.edu

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Summary
This study was designed to determine the effectiveness of marination, injection marination and/or vacuum tumbling as a means of alleviating the toughness associated with early deboning of breast. Broilers (n=480) 48-60 days of age were conventionally processed. Experimentally, a 2 X 2 X 8 factorial arrangement was used, in which replicates were considered different processing days. Fillets deboned at 2 and 4 h post mortem (PM) were subjected to the following treatments (n=15/treatment): 1. control, 2. tumble (T), 3. marination (M), 4. marination, tumbling (MT), 5. dry injection (I), 6. injection marination, tumbling (IMT), 7. dry injection, tumbling (IT), 8. injection marination (IM). When marinade was applied either by injection or brine-soaked, the marinade pick-up was 10% of the fillet weight to give a final concentration of 0.7% sodium chloride and 0.45% sodium tripolyphosphate per fillet. Biochemical parameters measured (n=80) included pH, sarcomere length, R-value. In addition, cook-loss and shear values were evaluated. In the fillets deboned at 2 h PM, injection marination treatments (IMT and IM) decreased cook-loss. In the fillets deboned at 4 h PM, all marination treatments (M, MT, IMT and IM) lowered the cook-loss compared to other treatment groups. At 2 h PM, the injection marination treatments (IMT and IM) lowered shear values compared to shear values of other treatments and the 4 h PM control. Also, in fillets deboned at 4 h PM, the marination treatments (M, MT, IMT and IM) lowered shear values below the 4 h PM control. This study suggests that the use of marination and injection marination could be an effective means of alleviating toughness associated with deboning fillets as early as 2 h PM.

Introduction
In the US, the per capita consumption of poultry has continued to rise since the 1960’s with the largest increase in production reported for further processed and convenience products. Because of the emphasis on value-added products, the poultry industry has become focused on improving product yield and meat quality. Common steps in further processing to create value-added poultry products include brining and marinating as an intermediary functional step or final step depending on the type of ready to market product being developed. Historically, the purpose brining and marinating meat was to preserve the meat. While meat preservation is still an important issue, today, brining and marinating are commonly used to increase yields by increasing water retention and improve meat quality characteristics, particularly meat tenderness.

The terms brining and marinating are often used interchangeably, yet they actually refer to two different processes. Brining typically, involves soaking the meat cut or whole muscle in a saltwater solution; therefore, the basic ingredients in any brine preparation would minimally include salt and water. In addition, brine formulations will include some type of phosphate, most commonly, sodium tripolyphosphate (STPP) (Barbut, et al., 1989). Salts and phosphates act synergistically to extract myofibrillar proteins that provide the cohesive network that holds a product together once it is cooked. Additionally, alkaline phosphates bind water and increase product juiciness. Other ingredients that may be used in a brine formulation include spices and seasonings such as sugar, honey, pepper, garlic, onion and other flavourings. Cure salts such and sodium nitrate are used in cured product formulations.

In the market, meat injected with salt/phosphate solutions products are typically referred to as “enhanced” while meat soaked in marinades are typically referred to as marinated product. Like
brining, acid marination evolved as a method of meat preservation; however, unlike brining, the process consist of soaking meat in seasoned or savoury acid liquid or sauce to enhance the flavour and tenderness of the meat (FSIS). Marinades typically include a mixture of oil and acidic liquids such as vinegar, lemon juice or wine and other spices. Salts and phosphates may also be used with marinades, but the pH of the system is lower than that of a typically brine formulation.

Today, the use of brines is typically referred to the process of marination regardless of the acidity or alkalinity of the functional ingredients used. As such, marination is often used as step to alleviate toughness associated with harvesting breast muscle early post-mortem. Prior to deboning, breast front halves should be aged 4-6 hrs to prevent adverse toughening (Stewart et al., 1984; Dawson et al., 1987). However, aging decreases speed of through put and product yield and increases labour and energy costs. Therefore, ways to alleviate the toughness associated with early deboning is a meat quality issue. Because alkaline marination systems may increase product tenderness, ways to optimize the chemical and mechanical benefits of the marination system are necessary identify.

There are several methods used to marinate or brine meat including immersing the meat in the brine or marinade solution, injecting with a brine or marinade solution, tumbling with a solution or injecting and tumbling. Injection marination is beneficial for its relative consistency of marination application on large and complex products, and reduction of labour and speed of marination. Tumbling promotes rapid and consistent pickup at controlled temperatures, the ability to marinate large quantities, and the capability to handle many different products and sizes. Because the steps may be used independently or in combination, it is important to understand the impact of the individual steps on product tenderness as well as the combined steps to determine the optimum combination to maximize meat tenderness. Therefore, the objective of this study was to determine the effectiveness of soak marination, injection marination and/or vacuum tumbling as a means of alleviating the toughness associated with early deboning of breast.

**Materials and methods**

**EXPERIMENTAL DESIGN AND PROCESSING CONDITIONS**

Broilers (480, 48-60 days of age) were processed. Following a 12 hour feed withdrawal, birds will be hung on shackles, electrically stunned using a stun-kill knife and killed by bleeding for 95 s from a single cut severing the right carotid artery and jugular vein. Subsequently, all birds will be hard-scaled at 56.6 C for 82s, defeathered in a picker for 42s, manually eviscerated and chilled using a 2-stage chilling regimen (tap water at 20 C for 15 min and ice-slush of static tap water at 2 C for 30 min.). These slaughtering methods are the standard methods used in commercial poultry slaughtering. The design will be a 2 X 2 X 8 factorial arrangement in which replicates are considered as different processing days. Treatment groups each containing 15 birds consisted of two deboning times (2 and 4 hours post mortem), each receiving the following treatments: 1. control, 2. tumble (T), 3. marination (M), 4. marination, tumbling (MT), 5. dry injection (I), 6. injection marination, tumbling (IMT), 7. dry injection, tumbling (IT), 8. injection marination (IM). The marination solution consisted of 0.7% sodium chloride, and 0.45% sodium tripolyphosphate (STP). The tumbling (45 minutes at 8 rpm) was performed using laboratory scale vacuum tumblers. Parameters that were measured on the chilled carcasses include cook-loss, shear value, colour, pH, R-value and sarcomere length.

**MARINATION EFFECTS ON COOK-LOSS AND SHEAR VALUES**

After removing the Pectoralis muscles (15 butterfly breast fillet/treatment group) at 2 and 4 hours PM, fillets were trimmed of excess skin and wings. Fillets were processed according to the treatments (1-8) mentioned above. Butterfly fillets were split in half and the right fillet was transferred to perforated plastic bags, and aged on ice (<2 C) for 24 hours. The left fillet was used in procedures described in the next section. After aging, the right fillets were weighed, placed on a wire grate sitting 2.14 cm above the bottom of a stainless steel pan and baked in an air-convection oven at 177 C to attain an internal temperature of 76 C. After fillets were removed from the oven and cooled to room temperature, the fillets were weighed again and cook-loss was determined by the ratio of cooked breast weight (g) / raw breast weight (g) X 100 (Sams, 1990). All cooked fillets were individually wrapped in foil, held overnight at 2 C and then subjected to shear analysis.

Shear analysis was performed on duplicate samples (dimensions are 40 mm x 20 mm x 7 mm, L x W x H respectively) cut from the cranial and medial portion of each fillet, with the long axis of the sample parallel with the muscle fibres. Samples were weighed and sheared perpendicular to the
direction of the muscle fibres using the (TA.XT2i) Texture Analyzer (Texture Technologies Corp., Scarsdale, NY/Stable MicroSystems, Godalming, Surrey, UK) equipped with a 10-blade Allo-Kramer shear compression cell and a 50 kg load cell. The two shear values for each bird were averaged and shear values were expressed as kg of force / g of sample (Sams, 1990).

**STRUCTURAL AND BIOCHEMICAL CHANGES ASSOCIATED WITH MARINATION**

The left fillets obtained from the previous section were examined for colour using the Minolta Colorimeter. Each fillet was analyzed by taking an average of 3 measurements from the anterior portion of the breast fillet. The Hunter L*a*b* system was used to express colour as follows; L (±, lightness/darkness), a (±, red/green) and b (±, yellow/blue) (Lewis et al., 2002). Raw muscle pH values were determined by the use of a hand-held pH meter equipped with a spear tip probe, with values taken in the anterior portion of each breast fillet.

After the colour and pH values have been determined, the left breast fillet was cut into three pieces (cranial, middle and caudal). The middle and caudal samples were frozen in liquid nitrogen immediately and stored at -80 C. In order to assess the extent of rigor mortis, the frozen samples were used (within a month) for the determination of R-value absorbance ratio (Thompson et al., 1987) and sarcomere length (Cross et al., 1980).

**Results**

[Figure 1: Cook-loss for fillets deboned at 2 hours PM.]
Figure 2  Colour values at 24 hours PM.

Figure 3  Fillet tenderness.
Utilizing marination to optimize tenderness: L.J. Bauermeister and S.R. McKee

Discussion

Cook loss was influenced by the different marinade applications. Specifically, all treatment groups with injected marination (IM) had less cook loss compared to the other treatments and the control group (Figure 1). These results suggest that injecting the marinade improves cook loss characteristics compared to tumble marination (MT) or soak-marination (M). Phosphates improve water retention through increasing the pH further away from its isoelectric point and by causing an unfolding of muscle proteins, making more sites available for water binding (Pearson and Gillett, 1996). Physical agitation of the meat by tumbling (T) had similar cook loss to controls while injecting (I) or combining tumbling and injecting (IT) had slightly lower cook loss than controls (Figure 1). It was expected that physical agitation may increase cook loss but this was not observed. Overall, injection of salt and phosphates was the best way to improve cook yield of breast fillets compared to controls.

L-values of breast fillets was decreased in all treatments where marination was used. This was consistent regardless of whether the marinade was injected or applied as a soak (Figure 2). Lower L-values suggest that the meat was darker in colour. Swatland (1993) found that the pale colour of meat is influenced by pH decline and light scattering properties of the meat. When light is scattered as opposed to absorbed, meat colour appears lighter. An example of this phenomena can be illustrated by the comparison of DFD (dark, firm, dry) and PSE (pale, soft, exudative). DFD meat has a higher pH and retains more water. Additionally, the surface of the meat appears darker because the light is absorbed as opposed to being scattered. In contrast, PSE meat has low water-holding capacity which results in light scattering characteristics thereby making the meat appear pale in colour. Because the phosphates slightly increase the meat pH and improve the ability of the meat to hold water, it is not surprising that the poultry breast fillets in the current study would have lower L-values and appear darker.

One of the most important meat characteristics is meat tenderness. Because the focus of this study was to determine the optimum marination application to alleviate toughness associated with broiler breast meat deboned early post-mortem, the individual affects of the various physical applications were determined as well as combinations of these applications with the marinade were evaluated. Injection marination (IM) with or without tumbling was sufficient to reduce shear values to that equivalent to the four hour control (Figure 3). The application of tumbling combined with injection marination (IMT) appeared to slightly increase shear values compared to injection marination (IM) without tumbling. Despite the slightly higher shear values of the IMT treatment group, the fillets would still be considered tender by the consumer. A common trend was observed with all meat that was tumbled. Specifically, tumbling resulted in slightly higher shear values when compared to the equivalent treatments not tumbled except for the treatment containing marination. For example, the application of tumbling (T) decreased shear values compared to the 2 hr control (Figure 3). Additionally, when injection (I) was combined with tumbling (T) higher shear values were observed. While physical treatments alone were not sufficient to tenderize meat, marination was optimized when combined with a physical treatment (Figure 3). Thus, marination with tumbling (MT) had improved shear values compared to marination without tumbling (M). Furthermore, injecting the marinade (IM) resulted in the lowest shear values and most tender meat compared to the other treatments. Combining marination with a physical process such as tumbling or injecting allows the marinade to be absorbed better thereby allowing the salt to unfold the myofibrillar proteins increasing binding sites and the phosphates to increases the electrostatic repulsion increasing the water holding capacity improving the tenderness of the product (Rust, 1987). Marination and tumbling (MT) was probably less effective than the injection treatment (IM) because the action of the salt and phosphate system was limited to the surface of the product.

Overall, this study suggest that combining the physical application of injection with marination improved tenderness of broiler breast fillets deboned at 2 hr post-mortem to that compared to broiler breast fillets aged on the carcass 4 hr before deboning.

References


