Effects of Stunning Duration on Quality Characteristics of Early Deboned Chicken Fillets

LOUIS L. YOUNG and R. J. BUHR

Richard B. Russell Agricultural Research Center, USDA-Agricultural Research Service, P. O. Box 5677, Athens, Georgia 30604-5677

ABSTRACT

The objective of this study was to determine effects of electrical stunning duration on quality of broiler chicken fillets. Seventy-two broiler chickens were electrically stunned for 0, 2, 4, 6, 8, or 10 s, slaughtered, and chilled. After 1 h post-mortem, both pectoral muscles were excised and cooked. Cooking loss, pH, cooked color values, and shear values were measured. As stunning time increased, pH and shear values significantly increased. Except for a small but significant increase in yellowness, color values were unaffected by stunning duration. Cooking loss was unaffected by stunning duration. These data indicate that stunning duration can affect post-mortem muscle metabolism as measured by pH change. Therefore, control of the process of slaughtering broilers requires careful regulation of stunning duration.

(Key words: stunning time, shear value, meat texture, muscle pH, meat color)

INTRODUCTION

As the poultry industry has become more involved in further processing, the importance of strict process control to maintain consistent meat quality is increasing. At the same time, quality characteristics that affect consumer acceptability are changing. Instead of emphasizing carcass characteristics, such as absence of defects and skin color, new emphasis is being placed on functional characteristics of the meat, such as texture, moisture binding, and color. These latter quality characteristics are directly affected by ante- and post-mortem glycolytic activity. In general, functional properties are enhanced when the muscle retains its chemical characteristics, such as ante-mortem levels of pH and intracellular calcium concentrations (Froning and Neelakantan, 1971; Young and Lyon, 1997).

Preslaughter electrical stunning, which is routinely used to immobilize poultry prior to mechanical killing, has been shown to alter both the rate of post-mortem glycolysis (Lee et al., 1976; Thomson, et al., 1986; Papinaho et al., 1995; Papinaho and Fletcher, 1996) and the functional characteristics such as texture (Thomson et al., 1986; Young and Lyon, 1997), protein solubility (Murphy et al., 1988), and color (Papinaho and Fletcher, 1996). However, most studies have compared results from stunned birds with those of unstunned birds or stunning at various currents or potentials. Little information has been published concerning effects of stunning duration on functional characteristics. Typically, processors in the U.S. stun broilers at about 50 V (alternating current) for 10 s or less; however, stunning conditions are usually adjusted to maintain efficient killing with minimal carcass damage rather than to maintain optimal functional characteristics. More information is needed on effects of stunning parameters on the biochemical and functional properties of the meat. The objective of this study was to evaluate effects of electrical stunning duration on some of these properties.

MATERIALS AND METHODS

Sample Preparation

Twenty-four commercially reared broiler chickens were obtained from the holding area of a local processor. The birds were transported to the laboratory in coops (travel time 15 min), where they were processed within 30 min. They were stunned in batches of four at a constant potential of 50 V (alternating current) for 0, 2, 4, 6, 8, or 10 s. Current varied between 30 and 32 mA. The birds were placed in metal cones to partially restrict movement and were killed by manually cutting one carotid artery and one jugular vein. After bleeding for 2 min, the birds were scalded at 56°C for 2 min and mechanically picked. The carcasses were manually eviscerated, washed, and held at room temperature until 30 min post-mortem, at which time they were chilled in agitated ice water (0 to 1°C) for 30 min. Chilling was delayed until 30 min post-mortem to simulate commercial conditions. The carcasses were...
removed from the chiller and allowed to drain for 10 min. Pectoral muscles were then excised, sampled for pH, and weighed \( (\text{wt}_i) \). Each fillet was vacuum-sealed in a cooking bag and cooked for 20 min in an 85°C water bath. Endpoint cooking temperature was 80°C. Endpoint temperature was monitored with cooking thermometers inserted into the geometric centers of two fillets in each cooking batch prior to vacuum sealing. After cooking, the bags containing the fillets were cooled by immersion in ice water for 20 min. The fillets were then removed from the bags, overwrapped with aluminum foil, and held overnight at 4°C. Cooking loss was calculated and then a sample was cut from the center of each fillet for shear value analysis. Color values were evaluated on the interior cut surfaces of each fillet. The experiment was replicated a total of three times using 24 fillets per stunning duration.

**Muscle pH Evaluation**

Duplicate 2-g samples of muscle tissue were dispersed in 25 mL of 5 mM iodoacetate containing 150 mM KCl. Each dispersion was mixed\(^1\) for 30 s, after which the pH was evaluated with a pH meter.\(^2\) Mean values of the duplicates were recorded as the pH of the muscle.

**Cooking Loss**

Effect of stunning duration on moisture binding properties of the fillets was evaluated as cooking loss. After removing the fillets from the cooking bags, the fillets were blotted dry and weighed \( (\text{wt}_e) \). Cooking loss was evaluated as:

\[
\text{Cooking loss} = 100 \times \frac{(\text{wt}_i - \text{wt}_e)}{\text{wt}_i}.
\]

**Color Values**

Commission International D’Eclairage (CIE) (1978) color values were measured in the center of each cooked muscle with a color meter\(^3\) that had been previously calibrated with a white tile. \( L^*, a^*, \) and \( b^* \). Measurements were made at three locations on each fillet, and the mean of the three measurements recorded as the color values of each fillet.

**Warner Bratzler Shear Values**

Cooked fillets were tempered for 30 min at 20°C to equilibrate temperatures of the fillets and then one 1.9-cm-wide strip was cut from the center of each fillet. The cuts were made through the entire thickness of the fillets and were parallel with the muscle fibers. Each strip was sheared once with a Warner-Bratzler shear device,\(^4\) and maximum force in kilograms required to shear was recorded as the shear value.

**Statistical Analyses**

The data were analyzed using ANOVA in which replicates, stunning duration, and birds within replicate by stunning duration were tested as main effects (Steel and Torrie, 1960). Main effects were tested for statistical significance \( (P < 0.05) \) using the residual error mean square. Least squares means were calculated for all dependent variables at each stunning duration, and the means were tested for statistical significance using Student’s \( t \) test \( (P < 0.05) \).

**RESULTS AND DISCUSSION**

**Muscle pH**

The pH of the muscles significantly increased as stunning time increased (Table 1). This observation is consistent with other studies that compared pH of early harvested muscles from stunned and unstunned birds. Those studies indicated that stunning temporarily delays the normal post-mortem decline in muscle pH, but the ultimate pH of muscle from stunned and unstunned birds does not vary (Goodwin et al., 1961; Lee, et al., 1976; Stewart, et al., 1984a,b). Early reports indicated that the main effect of electrical stunning on early rigor development was that it delayed glycolysis (Lee et al., 1976; Murphy et al., 1988). More recently, Papinaho et al. (1995) presented data from birds that were physically restrained during slaughter, which indicated that the main effect of electrical stunning on early rigor development was due to inhibition of peri-mortem struggle. In the present study, it was observed that the birds that received no electrical stunning exhibited a death struggle, but those that received any electrical stunning treatment, even for only 2 s, appeared to be unconscious and did not struggle. This

---

1. Polytron, Brinkmann Instruments, Westbury, NY 11590.
death struggle and the energy depletion that occurs is evidenced by the low muscle pH (5.79) in the unstunned group. Similar results were observed previously (Young et al., 1996). Thus, it appears that inhibition of peri-mortem struggle may not be the only effect of electrical stunning on rigor development, as pH values were higher with longer stunning times.

**Cooking Loss**

Cooking loss was unaffected by stunning duration (Table 1). This observation is consistent with those of Young et al. (1996) and Papinaho and Fletcher (1996) for early harvested breast meat. However, in the latter study, cooking losses of meat deboned 24 h post-mortem were greater than those of meat harvested shortly post-mortem.

**Color Values**

Previous reports on the effects of electrical stunning on color of poultry meat have not been consistent. Young et al. (1996) evaluated color values after 2 to 10 s stunning duration and found no effect of stunning on breast meat color. Papinaho and Fletcher (1995) described two experiments that evaluated effects of stunning amperage on color values of early harvested (15 min post-mortem) and delayed harvested (24 h) breast fillets. In one experiment, lightness values of early harvested (but not delayed harvested) breast fillets from stunned carcasses were significantly lighter than those from unstunned carcasses; however, in the second study, stunning did not affect color. In the present study, fillets from birds stunned for 10 s had slightly, but significantly, lower lightness values (L* = 81.9) and higher yellowness values (b* = 13.4) than unstunned controls (83.2 and 12.9, respectively), but lightness and yellowness values from carcasses stunned 2 to 8 s were similar to those from unstunned carcasses. Redness (a*) values were unaffected by stunning time. Considering the present results and those of other studies, it can be concluded that stunning does not have a consistent effect on breast meat color.

**Warner-Bratzler Shear Value**

Effects of electrical stunning on toughness of breast meat have not always been consistent. Goodwin et al. (1961) and Ma and Addis (1973) reported that electrical stunning did not affect shear values. Lee et al. (1976) found that stunning had no effect on shear values of muscles cooked immediately after chilling; however, muscles from stunned birds required greater force to shear than those from unstunned birds if cooking was delayed at least 4 h postchill. In yet another study, Boulgakova et al. (1977) observed that electrical stunning created a stress reaction in chickens that resulted in toughening of the meat. Papinaho and Fletcher (1996) found that electrical stunning increased toughness in broilers, but only for up to 10 h post-mortem and only if the stunning was performed at 125 mA. Stunning at 125 mA resulted in electrocution of the birds, whereas stunning at 50 mA resulted in immobilization, but not death. Stunning did not affect toughness after 10 h post-mortem or if the birds were stunned at 50 mA. The present study adds information about duration of stun that can affect the birds’ response to stunning and ultimate product quality. As stunning duration increased from 2 to 8 s, shear values also significantly increased (Table 1). The lowest shear values noted were for the birds that did not receive stunning treatment. It is unclear how this observation relates to previous studies, because stunning conditions and time post-mortem are not always clearly described. Moreover, muscles in the present study were evaluated immediately postchill only and under fixed stunning conditions. However, electrical stunning appears to consistently increase shear values of early deboned fillets compared to fillets from birds that receive no ante-mortem stunning.

The results of this and previous studies indicate that stunning conditions can influence the ultimate quality of poultry products. Consistent meat quality has become increasingly important to the poultry industry as more poultry is further processed. Consistent quality demands improved process controls, and the industry is presently improving that control. To further improve quality controls, processors may need to examine the roles of multiple parameters associated with stunning, including stunning duration, if they are to optimize control over the process of poultry slaughter.

**REFERENCES**


