Effect of Vacuum on Moisture Absorption and Retention by Marinated Broiler Fillets

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ABSTRACT Effects of vacuum on moisture retention and quality characteristics of aged chicken breast fillets were evaluated. One hundred twenty-eight broilers (2 replicates of 64 birds each) were manually slaughtered, chilled in ice water, placed in unsealed plastic bags, and then aged overnight at 4°C. Both pectoralis major muscles were harvested from each carcass. Left muscles were marinated for 30 min en vacuo with 20% (vol/wt) of a 10% NaCl (wt/vol) solution containing 4% (wt/vol) commercial food-grade polyphosphate. Right fillets were marinated similarly but without vacuum. Moisture absorption, cooked yield, pH change during marination, and shear values of vacuum-marinated fillets were compared to those on fillets marinated without vacuum. Use of vacuum during marination increased moisture absorption during marination, but after cooking, yields were similar. Nor did vacuum effect pH or shear values. Under the conditions of this study, use of vacuum during marination appeared to offer no significant advantage over marination at atmospheric pressure.

(Key words: chicken, poultry, marinate, meat)

INTRODUCTION The proportion of poultry marketed in the United States as further processed product has grown steadily for many years. In 1980, only about 10% of chicken meat was further processed prior to marketing. That figure increased to 26% by 1990 and to 45% by 2000, and that trend is likely to continue into the foreseeable future (National Chicken Council, 2003). Smith and Acton (2001) estimated that 50% or more of total pounds of broiler meat produced is marinated prior to consumption. Manufacturers of these further processed products often marinate the raw meat in various solutions to improve texture, flavor, and saleable yield.

A few studies evaluating factors that affect marinade uptake and retention have been described, but basic questions regarding the mechanisms involved in the marination process have not been answered. Young et al. (1996) evaluated effects of stunning duration on color, pH, and texture of polyphosphate-marinated early-harvested broiler breast fillets. They reported that polyphosphate-marinated meat was darker and less red than meat marinated without phosphate. One-hour postmortem pH values increased as stunning duration increased, but marination with or without polyphosphate eliminated this trend. Shear value became greater with increasing stunning times but were unaffected by the polyphosphate marinade. Young and Lyon (1997) showed that polyphosphate marination of bone-in chicken forequarters immediately postslaughter can lead to high shear values. Marinade absorption was unaffected by time postmortem at which the parts were marinated, but those marinated 3 h or more postmortem retained less marinade than did those marinated earlier. This apparent toughening effect is suppressed if carcasses are electrically stimulated during exsanguination, but at the expense of reduced cooked yield (Young et al., 1999). Allen et al. (1998) evaluated relationships among color, quality, and shelf life of marinated broiler breast meat. Meat pH was unaffected by marination, but psychrotrophic plate counts of marinated breasts was lower than those of controls. Darker breasts had higher pH values and absorbed more marinade than did lighter breasts. Qaio et al. (2002) studied effects of broiler breast fillet color on pH and marinade absorption and retention. They found very dark meat exhibited higher pH, greater marinade absorption and cooked yield, and reduced shear values compared with lighter meat.

Equipment manufacturers have devised various schemes for increasing marinade uptake and improving product quality. Among the most widely common is use of vacuum during marination. Equipment manufacturers’ advertising materials tout the efficacy of vacuum marination in hastening marination and promoting greater marinade retention compare with marination at ambient atmospheric pressure, but rigorous peer-reviewed studies...
TABLE 1. Effect of vacuum on pH change, moisture absorption and retention and shear values of marinated chicken breast fillets

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>pH change</th>
<th>Marinade absorption (%)</th>
<th>Yield (%)</th>
<th>Shear value (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (no vacuum)</td>
<td>128</td>
<td>+0.30</td>
<td>8.3^b</td>
<td>91.9</td>
<td>2.08</td>
</tr>
<tr>
<td>Vacuum marinated</td>
<td>128</td>
<td>+0.30</td>
<td>9.3^a</td>
<td>92.4</td>
<td>2.09</td>
</tr>
<tr>
<td>SEM</td>
<td>0.01</td>
<td>0.17</td>
<td>0.28</td>
<td>0.07</td>
<td></td>
</tr>
</tbody>
</table>

^a,bMeans in the same column sharing no common superscripts differ significantly (P < 0.05).

are not readily available in the scientific literature. The objective of this study was to evaluate effects of vacuum on moisture retention and quality characteristics of marinated chicken breast fillets.

METHODS AND MATERIALS

Sample Preparation

One hundred twenty-eight commercially reared mixed-sex 40-d-old broiler chickens (2 replicates of 64 birds each) were procured from the holding area of a local poultry processor. The birds were deprived of feed for 6 to 8 h and deprived of water for 4 h. They were transported in conventional coops about 8 km to the pilot processing facility where they were immediately electrically stunned (50 V alternating current for 10 s), killed by exsanguination with 2 min bleeding time, scalded for 2 min at 55°C, mechanically picked, and manually eviscerated. Each carcass was chilled for 30 min in mechanically agitated 5°C ice water, placed in a plastic bag, and stored overnight in a 4°C cold room.

Marination

Left and right breast fillets (pectoralis major) were excised from each carcass. Left fillets were marinated for 30 min en vacuo with 20% (vol/wt) of a prechilled (4°C) 10% (wt/vol) NaCl solution containing 4% (wt/vol) commercial food-grade sodium tripolyphosphate. Right breasts were marinated similarly but at ambient atmospheric pressure. Marination was carried out with dual Injectstar MC 40 tumble-marinators equipped with a 40-L stainless steel vacuum marination container. Marination vacuum condition for the left breasts was 50 kPa, and all marination was carried out in a 4°C room. A vacuum was drawn with a vacuum pump, and the containers remained sealed during the marination process; fillets were not injected. The fillets were then cooked.

pH Determination

Each fillet was sampled for pH determination immediately before (premarination pH) and after (postmarination pH) marination. Muscle pH was determined using the iodoacetate method of Jaecocke (1977) as modified by Sams and Janky (1986). Duplicate 2-g samples of tissue from the posterior end of each fillet were individually manually chopped and then blended with 25 mL of 5 μM iodoacetate solution containing 150 mM KCl. pH of the resulting slurry was evaluated within 4 h using a Sentrom Model 2001 pH system. pH change during marination was calculated by subtracting premarination pH of each muscle from its postmarination pH.

Moisture Absorption

Each fillet was weighted after sampling for premarination pH. After marination, surface moisture was removed with a paper towel, and the fillets were reweighed before sampling for postmarination pH. Moisture absorption was calculated by difference and expressed as a percentage of premarination weight.

Cooking

Each fillet was vacuum-sealed in an individual cooking bag and cooked by immersion for 20 min in an 85°C steam-heated thermostatically-controlled water bath. Preliminary studies showed that endpoint temperature of breast fillets similar to those used in this study cooked in this fashion was 80°C. After cooking, the fillets were cooled by immersing the bagged fillets in ice water for 20 min.

Shear Values

Shear value of each muscle was evaluated as in a previous study (Young et al., 1991). A strip 1.9 cm wide was cut from through the complete depth of each cooked and cooled fillet beginning at the humoral insertion and ending at a point adjacent to the keel. Shear value (in kg) was assessed by shearing across the fibers using a Warner-Bratzler shear device.

Statistical Analysis

Data were analyzed pairwise using Student’s t-test at P < 0.05 to test for significant differences between fillets marinated en vacuo and those marinated at ambient atmospheric pressure.

2 BK-Ladenberg Corporation, Catskill, NJ.
Inject Star, Brookfield, CT.
Sentrom Integrated Sensor Technology, Federal Way, WA.
RESULTS AND DISCUSSION

pH change during marination, cooked yield, and shear value were unaffected by vacuum (Table 1). As in previous studies (Young and Lyon, 1994, 1997; Young et al., 1996a,b, 1999), mean pH increased during polyphosphate marination in the present case by 0.30 units for control and vacuum-marinated fillets. The vacuum treatment increased marinade absorption by 1.0%, but the additional absorption was lost prior to cooking or during cooking. The percentage of marinade absorbed by both control and vacuum-marinated fillets (8.3 and 9.3%, respectively) was lower than levels typical for industry but reasonable for small laboratory tumbler. The lower pickups allowed the fillets to absorb less phosphate than the USDA-mandated level of 0.5%. Vacuum also did not alter shear value, as both control and treated fillets exhibited shear values averaging 2.085 kg. Lyon and Lyon (1991) reported the Warner-Bratzler shear values that correspond to sensory perception of tenderness using an untrained 24-member panel. Their benchmarks indicate that the shear values of both groups of fillets in the present study correspond to very tender. Many of the studies cited previously involved meat harvested shortly postmortem before resolution of rigor, whereas those used in this study were removed after the carcasses were aged over night. It is possible that if this study was repeated with early harvested fillets, the outcome would differ. Nevertheless, the conclusion drawn from this study must be that under the conditions applied here, use of vacuum during marination offered no real advantage in terms of yield or texture of the final product.

REFERENCES


