A Research Note

Bacteriology of Hot and Cold Boned Pork Preblends

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(Received for publication February 24, 1992)

ABSTRACT

Ground pork and preblends containing 2% NaCl or 2% NaCl plus 200 ppm NaN0 2 were prepared from hot (HB) and cold (CB) boned pork in a commercial slaughtering plant. Total aerobic mesophiles, psychrotrophs, Enterobacteriaceae, salt tolerant, and lactic acid bacteria were enumerated in freshly ground meat and in preblends stored for 1 week at 2°C. Boning method had no effect on mesophilic, psychrotrophic, and salt tolerant counts in freshly ground meat, but Enterobacteriaceae and lactic acid bacteria were found in higher numbers in CB than HB meat (P < 0.05). Addition of salt plus nitrite led to the inhibition of most bacterial groups, although lactic acid bacteria were found in higher numbers in HB preblends after one week of storage (P < 0.05). The data revealed that HB pork preblends of excellent bacteriological quality and stability can be produced in an industrial context.

Traditional meat processing schemes utilize raw materials derived from chilled carcasses that have entered into rigor mortis. Since postrigor muscle has limited ability to bind water, phosphates, or functional ingredients which have a high water-holding capacity (WHC) are often incorporated into processed meat formulations. The use of such additives may be circumvented by processing muscle in the prerigor or "hot boned" state (17). Prerigor muscle has excellent WHC since the postmortem metabolic events which lead to a reduction in pH and a shift toward the isoelectric point of myofibrillar proteins are incomplete (13). Immediate grinding and salting preserve the enhanced WHC of prerigor muscle and provide a means by which hot boning can be adapted to existing slaughter and processing operations (6,15). Preblends prepared in this fashion may be used in formulations for comminuted products with positive effects on the WHC and desired functional properties (1,2,15). In addition, significant savings in production costs (energy, refrigeration, space, etc.) have been demonstrated for hot boning (9,10).

Despite proven technological advantages, the industrial adoption of hot processing has been slow. Economic factors have contributed to this situation, but concerns about the microbiological quality of hot boned meat products have also hindered industrial applications. Dressing and cutting carcasses immediately after death lead to contamination of high pH meat at temperatures near physiological values, thereby increasing the potential for accelerated proliferation of microorganisms (11). Reports published to date contain conflicting observations on the bacteriological quality of hot boned pork preblends. Davidson et al. (4), Lin et al. (12), Judge and Cousin (8), and Choi et al. (2) have indicated that ground hot boned pork harbors higher numbers of bacteria than ground cold boned meat. The practice of preblending is advocated by Schwagele et al. (15), however, who reported that hot boned pork preblends can be stored for extended lengths of time at refrigeration temperatures without compromising microbiological quality.

The conclusions reached by the aforementioned authors were mostly drawn from observations obtained in laboratory or pilot plant studies. Further research is therefore required to determine if hot boned pork preblends of acceptable quality can be produced in an industrial context. The purpose of this study was to determine the bacteriological quality of fresh and stored preblends prepared from hot boned meat processed under commercial conditions.

MATERIALS AND METHODS

Experiments were performed in a federally inspected hog slaughtering plant in the Province of Québec (kill rate 500 head per hour) on three separate production days. Dressed and inspected carcasses were selected at random on the rail (approximately 30 min postmortem) and were appraised visually. Two carcasses with normal muscle color were chosen at each sampling and were processed simultaneously. One shoulder was immediately removed from each hot carcass (HB), and the remainder of the carcass was cooled according to standard plant practice (spray chilling) for 24 h. The opposite shoulders (CB) were then removed and processed as described below.

Both HB and CB shoulders were manually boned and trimmed of excess fat on a cutting table set up in one of the plant coolers (ambient temperature: 10°C). Exposed surfaces and processing equipment were rinsed with hot water, but not sanitized, between...
morning and afternoon shifts. The meat from both shoulders was pooled and ascribed to one of three treatments which was repeated twice during each production day to yield a total of six replicates: i) control, ii) addition of 2% (wt/wt) NaCl, and iii) addition of 2% NaCl and 200 ppm NaN0₂. The meat was ground through a 12-mm plate and blended with or without salts for 1 min on a Hobart Mixer fitted with a flat paddle (Model A200T, Hobart Canada, Inc., Don Mills, Ontario). Preblend temperatures and pH (six replicates) were measured immediately after mixing with a hand held pH Meter (Corning Model 105, Corning, NY) equipped with a temperature probe and a spear type combination electrode (Ingold Electronics, Inc., Andover, MA). Rectangular plastic containers were filled with preblend (1 kg per container, thickness approximately 5 cm), covered with saran, and stored for 1 week in a cooler at 2°C.

Sampling for bacteriological analysis was performed prior to mixing the ground meat with salt (t₀) and after 1 week of storage (t₁). Two 11-g samples were withdrawn from each thoroughly mixed preblend and were homogenized for 2 min in 0.1% peptone with a Stomacher (Colworth, England). Aliquots (0.1-ml) of suitable dilutions were spread plated onto the following culture media for the enumeration of individual bacterial groups: Plate count agar incubated for 48 h at 30°C for total aerobic mesophilic counts; plate count agar (7, 7°C) for enumeration of psychrotrophic bacteria; plate count agar supplemented with 5% NaCl (48 h, 30°C) for enumeration of salt tolerant bacteria; violet red bile agar (48 h, 37°C) for presumptive enumeration of Enterobacteriaceae; MRS agar incubated for 48 h at 25°C in a H₂ + CO₂ atmosphere generated with GasPak kits (BBL Microbiology Systems, Cockeysville, MD) in anaerobic jars for presumptive enumeration of lactic acid bacteria. Peptones and culture media were purchased from Difco Laboratories (Detroit, MI).

Data were analyzed as a split plot design (16), and analysis of variance was performed using the SAS analytical program (14).

RESULTS AND DISCUSSION

Temperatures and pH values were consistently higher in preblends prepared with HB than CB meat (Table 1). The potential for accelerated microbial growth under such conditions has led to concerns about the quality and stability of products derived hot boned meat and prompted the present investigation. Bacterial counts in freshly ground carcasses ultimately alter the bacterial profile of skin. Bacteria that grow poorly at refrigeration temperatures, notably the staphylococci and micrococci, are gradually displaced by more cold tolerant species (7). Consequently, the microflora of meats derived from carcasses processed immediately after death or 24 h postmortem differ, as shown by Erichsen et al. (5). These authors found that mesophilic micrococci were dominant on hot boned pork loin roasts while gram-negative psychrotrophs were more abundant on the same cuts from conventionally cooled carcasses. Although the differences between boning treatments were not always statistically significant, a similar pattern was noted in the present results. Mean counts for salt tolerant and mesophilic bacteria were higher in HB than CB meat, while the opposite was true for psychrotrophs, lactic acid bacteria, and the Enterobacteriaceae.

TABLE 1. Mean temperatures and pH of hot boned and cold boned unsalted meat (U) and preblends treated with 2% NaCl (S) or 200 ppm NaN0₂ (N). Each mean is followed by the standard deviation. Measurements were taken immediately after mixing.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cold boned</th>
<th>Hot boned</th>
<th>Cold boned</th>
<th>Hot boned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH</td>
<td>Temperature (°C)</td>
<td>pH</td>
<td>Temperature (°C)</td>
</tr>
<tr>
<td>U</td>
<td>5.77±0.24</td>
<td>6.19±0.23</td>
<td>9.16±1.33</td>
<td>23.22±1.13</td>
</tr>
<tr>
<td>S</td>
<td>5.90±0.26</td>
<td>6.19±0.23</td>
<td>8.77±1.20</td>
<td>21.79±2.37</td>
</tr>
<tr>
<td>S,N</td>
<td>5.92±0.23</td>
<td>6.29±0.24</td>
<td>8.78±1.10</td>
<td>21.83±1.41</td>
</tr>
</tbody>
</table>

Since the shoulders were both skinned and boned on the same table, it was assumed that bacterial contaminants came from the skin and were transferred to meat through contact with surfaces and knives. The number and nature of microorganisms on porcine skin can vary considerably, but the normal flora is believed to consist primarily of salt tolerant staphylococci and micrococci, pseudomonads, and Enterobacteriaceae (7). Counts in freshly ground meat were consistent with the assumption that skin was the greatest source of contaminants since salt tolerant bacteria were always the dominant bacterial group, particularly in preblends made from HB meat. Interestingly, the Enterobacteriaceae were detected in low numbers in HB preblends although Ingram and Simonsen (7) indicated that they are normally found in very high numbers on pork skin. The work of Erichsen et al. (5), Christensen and Sorensen (3), and the present observations suggests the Enterobacteriaceae are a minor component of the carcass microflora.

Selective pressures during slaughter and cooling of carcasses ultimately alter the bacterial profile of skin. Bacteria that grow poorly at refrigeration temperatures, notably the staphylococci and micrococci, are gradually displaced by more cold tolerant species (7). Consequently, the microflora of meats derived from carcasses processed immediately after death or 24 h postmortem differ, as shown by Erichsen et al. (5). These authors found that mesophilic micrococci were dominant on hot boned pork loin roasts while gram-negative psychrotrophs were more abundant on the same cuts from conventionally cooled carcasses. Although the differences between boning treatments were not always statistically significant, a similar pattern was noted in the present results. Mean counts for salt tolerant and mesophilic bacteria were higher in HB than CB meat, while the opposite was true for psychrotrophs, lactic acid bacteria, and the Enterobacteriaceae.

TABLE 2. Mean log bacterial counts (log CFU/g) of hot and cold boned pork preblends at the time of mixing (t₀) and after one week (t₁) of storage. Unsalted meat: U; 2% NaCl added: S; 200 ppm NaN0₂ added: N. Each mean represents the mean of duplicate counts performed on six replicates.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Mesophiles</th>
<th>Psychrophots</th>
<th>Salt tolerance</th>
<th>Lactics</th>
<th>Enterobacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CB*</td>
<td>HB</td>
<td>CB</td>
<td>HB</td>
<td>CB</td>
</tr>
<tr>
<td>t₀</td>
<td>3.30±</td>
<td>3.72±</td>
<td>2.28±</td>
<td>2.18±</td>
<td>3.51±</td>
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<tr>
<td>t₁,U</td>
<td>3.35±</td>
<td>3.74±</td>
<td>4.10±</td>
<td>4.01±</td>
<td>3.63±</td>
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<tr>
<td>t₁,S</td>
<td>2.86±</td>
<td>3.37±</td>
<td>3.33±</td>
<td>2.22±</td>
<td>3.03±</td>
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<tr>
<td>t₁,S,N</td>
<td>3.04±</td>
<td>3.33±</td>
<td>2.68±</td>
<td>2.01±</td>
<td>3.11±</td>
</tr>
</tbody>
</table>

*Mean values with common superscripts (columns) or underscoring (rows) are not significantly different (P > 0.05).
Values are a pooled mean for samples of each preblend at the time of mixing.
ences in the bacteriological profiles of HB and CB ground meat were therefore qualitative rather than quantitative. Elevated mesophilic counts in ground HB pork have been observed by other researchers (4,12) who also reported parallel psychrotrophic counts, in contrast with our observations. These divergent results are surprising given the nature of bacterial contaminants in fresh hot boned meat. They possibly resulted from differences in the processing environment since the previous investigations were conducted in laboratory settings, unlike the present which was performed with carcasses produced under commercial conditions.

The effect of storage and salting on the bacteriology of HB and CB preblends is also shown in Table 2. Mesophilic, salt tolerant, and Enterobacteriaceae counts did not change in unsalted preblends stored for 1 week, but psychrotrophic bacteria (both treatments) and lactic acid bacteria (HB) counts increased significantly. Addition of salt impeded the growth of psychrotrophic bacteria in HB preblends, but the effect was not observed in CB preblends. However, psychrotrophic counts were maintained at a level comparable to that in fresh ground meat when salt and nitrite were used together, a result consistent with the expected bacteriostatic activity of these additives in meat (7). Most of the other bacterial groups were affected in similar fashion, but lactic acid bacteria counts increased significantly in HB preblends. The reasons for the latter observation are unknown.

The total bacterial loads determined in stored pork preblends were of the same order of magnitude (10^2-10^4 CFU/g) as those determined by Choi et al. (2), Lin et al. (12), and Schwagele et al. (15) in laboratory experiments. The buildup of microorganisms on tables and conveyor belts in a continuous boning line cannot be duplicated in the laboratory. For this reason, the present investigation was performed in a processing environment under conditions that permitted accumulation of microbial contaminants on work surfaces. Although these conditions only approximate those found in large scale operations, the results suggest that hot boned pork preblends of excellent bacteriological quality can be produced in an industrial setting. In addition, preblends containing salt and nitrite were stored for a period of 1 week without compromising bacteriological stability, indicating that longer storage periods are feasible particularly at lower refrigeration temperatures. Given their stability, such preblends could be transported to secondary processing facilities or stored for later use, thereby providing the versatility required to permit industrial application of preblending with hot boned pork.

REFERENCES