Changes in the Characteristics of Pork Cured in Salt-Reduced Brine

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Sodium chloride (NaCl) plays a vital role in developing flavor, and in enhancing the binding and antimicrobial properties of cured meat. On the other hand, consumers are demanding more meat products than ever with lower NaCl content for fear of cardiovascular disorder. NaCl levels in commercial hams are approximately 2.8%, while in a special formulation NaCl is reduced to 1.5% to provide "health food".

Polyphosphates can replace NaCl to some extent to improve binding and water holding properties and they also protect against rancidity. But consumers are tending to avoid phosphates used as food additives, claiming that the Japanese ingest more than a sufficient amount of dietary phosphates from other foods.

Mainly for economical reasons, the curing process has been accelerated in recent years, which is the chief cause of the insufficiently developed cured flavor of meat products. However, when prolonged curing is practised using NaCl-reduced brine, it may cause spoilage and depress water holding capacity; investigations are required in these respects.

An experiment was made to investigate the properties of pork cured in brine, the components of which were the same as ordinarily used in our laboratory except for NaCl which was reduced from 10% to 5% without any polyphosphates added.

Materials and Methods

Experimental treatments

Pork loin was purchased from a local market 3 days post mortem, stored overnight in a refrigerator, and then cut in a direction transverse to the muscle fiber into pieces 5 cm thick. These weighed approximately 300 g each, were immersed in 500 ml

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of brine containing 5% or 10% NaCl, and put into individual containers and kept in a refrigerator at 4°C. The components of the brine were: 500 g or 1,000 g NaCl, 100 g sugar, 40 g potassium nitrate and 40 g pepper in 10 l of water. After 1, 2 and 3 wks, two pieces each from both brines were used to analyze characteristics. Duplicates of pork pieces just prior to curing were used as the uncured control (0 wk).

Analytical methods

pH: A columnar piece of L. dorsi muscle was cut out from each piece, having full length from one side of the cut surface of the piece to the other and weighing 10 g. This was blended with 20 ml of distilled water for 3 min in ice water. A glass-electrode pH meter was used for measuring pH.

NaCl: A small amount (approximately 5 g) of ground NaCl sample was mixed with distilled water, kept overnight and the volume was made up to 100 ml. An aliquot was taken and Cl was analyzed by the Mohr titration method12).

Water content: Ground samples of approximately 2 g each were weighed in aluminum weighing trays, dried in an oven for 2 hr at 100 ±1°C, cooled in a desiccator and weighed again. Losses in weight were estimated as water.

Water holding capacity (WHC): Samples were ground with a food cutter (National, Cook Master MK-6000) at high speed for 20 seconds. A small amount (approximately 10 g) was put into a beaker and distilled water of 25% sample weight was added. (3 M NaCl solution was added in case of the uncured control.) After being mixed gently, the homogenate was allowed to stand for 60 min. These procedures were carried out in a walk-in refrigerator. Each sample was then divided into four test tubes, each having a stopper and containing 2 g tissue paper at the bottom, heated in a water bath at 70°C for 10 min, cooled with running tap water and centrifuged at 750 × g for 4 min. The remaining water percentage after centrifuging was regarded as WHC. When the WHC of uncured meat (0 wk) was determined, graded levels of NaCl solution besides 3 M were also tested.

Volatile basic nitrogen (VBN): Ground samples were deproteinized via a 4% trichloroacetic acid solution and VBN was analyzed by the microdiffusion method described by Conway13).

Statistical analyses: Data obtained were statistically analyzed by the SNEDECOR and COCHRAN14) method for a two-factor experiment.

Results and discussion

Results are shown as treatment means in Table 1. Curing increased the water content of meat as a result of hypertonic salt solutions causing the swelling of muscle fibers15). The water content increased gradually through the curing periods, with the increase from 0 to 1 wk (P < 0.01) and from 2 to 3 wks (P < 0.05) being significant. Mean water content of the meat cured in the 5% NaCl brine was significantly (P < 0.05) higher than that cured in the 10% NaCl brine.

Sodium chloride levels of the brines did not significantly affect the WHC of meat cured in them. However, weekly differences were highly significant; curing meat for
any length of time tested (1-3 wks) increased its WHC as compared to the uncured meat (P < 0.01), the values at 1 wk being the highest (P < 0.05).

Uncured samples (0 wk) were used to determine the relations of NaCl levels to WHC. WHC was highest (68.95-68.98, not shown in the table) when 3-3.5 M NaCl solution was used, and decreased when NaCl levels were changed in either direction. This agreed with the results of WIERBICKI et al., who observed the least shrinkage in meat with 3-5% NaCl added, either with or without supplemented phosphates. The addition of 3 M NaCl solution to 1/4 of the weight of ground meat corresponds to 4.39% NaCl in the cured meat with 1/4 the amount of distilled water added. Thus, 1 wk’s curing in 10% brine resulted in the most favorable NaCl level for WHC (4.45%, not shown in the table); these samples actually showed the highest WHC value (72.3, not shown in the table). The reason that cured meat had higher WHC than uncured meat was presumably because the time after NaCl addition was different between cured and uncured meats (1-3 wk curing periods vs. 1 hr); it may not be sufficient that myofibrillar proteins be solubilized for them to enhance WHC but a portion of them must be extracted. REAGAN et al. reported that the smokehouse loss of sausage decreased as storage time increased. As shown in Table 1, the meat cured in the brine with the higher NaCl level naturally contained more NaCl (P < 0.001). Weekly increases of NaCl levels were also highly significant (P < 0.001) until 2 wks when they reached a plateau.

The pH of meat samples increased slightly during curing. In the brine the pH decreased sharply from 0 to 1 wk (P < 0.001), and continued to decrease gradually. The pH values of both meat and brine were lower in 5% brine than in 10% brine, which corresponded with the higher VBN values in 5% brine than in 10% brine. These facts indicated that microbial activity was higher in 5% brine, resulting in more VBN and acid production. The sharp pH decrease in brine from 0 to 1 wk indicates lactic fermentation of the sugar, a component of the brine. The abruptly decreasing VBN

### Table 1. Mean values of some characteristics of cured pork loins and brines used

<table>
<thead>
<tr>
<th>Treatment variables</th>
<th>Pork loins</th>
<th>Brines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
<td>WHC</td>
</tr>
<tr>
<td>Brine NaCl*</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>10%</td>
<td>72.21</td>
<td>71.03</td>
</tr>
<tr>
<td>5%</td>
<td>73.15</td>
<td>70.33</td>
</tr>
<tr>
<td>Period of curing b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 wk</td>
<td>71.55</td>
<td>68.95</td>
</tr>
<tr>
<td>1</td>
<td>72.63</td>
<td>72.18</td>
</tr>
<tr>
<td>2</td>
<td>72.85</td>
<td>70.45</td>
</tr>
<tr>
<td>3</td>
<td>73.70</td>
<td>71.13</td>
</tr>
</tbody>
</table>

b) Means of duplicates over 5-10% NaCl. N= 4.

Mean values in the same column within treatments bearing different superscripts are significantly different (P<0.05).
values in the meat samples from 0 to 2 wk (P < 0.001), on the other hand, suggested that VBN in the meat samples was extracted by the brines, the pH values of which were on the acidic side after 1 wk. VBN levels continued to increase in the brines (P < 0.001), while those in the meats rose only during the last week of curing (P < 0.05). The values at the end of curing (3 wks) were still very low and no sign of spoilage was observed.

According to Terrell, increasing the NaCl content of processed meat products generally results in greater WHC, improved flavor scores, decreased microbial numbers, improved texture, and increased death loss of viable trichina larvae, but it may accelerate rancidity; the opposite effects are generally true when NaCl content is lowered. In the present experiment, the NaCl content of the meat samples cured in 5% brine (2.41% at 1 wk, not shown in the table) was not low enough to be called “NaCl-reduced meat products”. It was because 1) the size of the meat samples cured was small and 2) the samples were not soaked after curing. In order to reduce brine NaCl any further, some other measures should be taken to ensure microbiological preservation and safety of the products prior to any other quality attributes.

Vacuum packaging has been proposed as one of the effective measures against spoilage because most spoilage organisms are aerobic. Sodium acid pyrophosphate has been reported to delay the toxin production and growth of Clostridium botulinum. Anderson and Witter used some humectants to depress water activity of the brine, while Tsang et al. used organic acids to control the brine pH; these are effective against either spoilage bacteria or Clostridium botulinum. Romans and Ziegler mentioned that sugar was an important ingredient of brine for lowering its pH. Among some chloride salts as replacers of NaCl, Terrell reported that KCl was the best except for its detrimental effects on flavor, because KCl has almost the same functional and economic properties as NaCl.

References

5) Yoshida, N., Personal communication.
Pork Curing in Salt-Reduced Brine


