Color Stability and Sensory Attributes of Chicken Frankfurters Made With Betalains and Potassium Sorbate Versus Sodium Nitrite

K. P. VERELTZIS and E. M. BUCK*

Department of Food Science and Nutrition, University of Massachusetts, Amherst, Massachusetts 01003

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ABSTRACT

Chicken frankfurters made with 0.48% liquid beet juice concentrate containing betalains plus 0.20% potassium sorbate were compared to frankfurters made with sodium nitrite. The color of frankfurters made with natural pigments was more stable than nitrite-franks when exposed to light and oxygen over a 20-d storage period. Sensory panelists were unable to detect a difference between the flavor or texture of the experimental franks when tested under red light to mask color differences. There were no significant differences between Warner Bratzler shear values for franks from the two treatments.

Sodium nitrite and sodium nitrate have been used for many years to develop the characteristic color of cured meat products. In addition to color development, nitrites contribute to flavor development and prevent bacterial growth, especially that of Clostridium botulinum (22,23).

Recently, it has been shown that nitrite may react with certain nitrogenous organic substances to produce N-nitrosamines, which act as potent chemical carcinogens in experimental animals. There is no evidence at present that exposure to N-nitroso-compounds has been responsible for any human cancer; however, the carcinogenic potency of these compounds in experimental animals is such that the hazard to humans needs to be continually monitored (10).

Nitrosamines have been detected in many meat products. Fazio et al. (9) reported levels of nitrosopyrrolidine (NPYR) ranging from 10 to 100 ppb in fried bacon, and 45 to 207 ppb in bacon fat rendered during cooking. Crosby et al. (7) found 1-4 ppb of N-nitrosodimethylamine (NDMA) in luncheon meat samples.

The purpose of this investigation was to determine differences in color stability and sensory panel acceptance of chicken frankfurters made with betalains and potassium sorbate versus sodium nitrite. Microbiological performance of the system will be discussed in a subsequent paper.

MATERIALS AND METHODS

Preparation of samples

Chickens used in this experiment were 1-year-old culled males and females obtained from the University of Massachusetts Poultry Farm and slaughtered in the department meat laboratory. Carcasses were kept on ice overnight, then packaged and frozen at -20°C until needed. Chickens were thawed overnight at 4°C and then deboned by hand. Breast muscle was used as a source of white meat while thighs and drumsticks were used as a source of dark meat. The skin was removed from all chicken parts before grinding and was not used in the formulation. The final ratio of dark meat to white meat was approximately 2:1. Two separate batters were made at the beginning of the experiment, one nitrite and one betalains-sorbate. These yielded sufficient product for the storage study.

The basic poultry frank formulation was as follows: lean meat 78.9%, pork fat 10.8%, salt 2.6%, ice 5.0%, potato starch 0.8%, sugar 0.6%, dextrose 0.2%, corn syrup 0.6%, ground black pepper 0.08%, garlic powder 0.05%, sodium triphosphate 0.16%, paprika 0.11%, coriander 0.048%, sodium erythorbate 0.032%, and sodium nitrite 0.149%. In the natural pigment experimental franks, 0.48% liquid beet juice and 0.2% potassium sorbate were substituted for the nitrite. The liquid beet juice concentrate was Color-Treme R-111 supplied by Beatrice Foods, Inc., Chicago, Illinois. The beet juice concentrate contained 0.59% betalains of which 39% was betanin. The sausage mix contained, therefore, approximately 19 ppm betanin.
The lean meat was ground through a 1/8-inch plate and then was placed in a "Stroma" cutter (model C20 IN 106) equipped with three knives. The salt, spices, and 1/2 of the ice were added and the entire meat mass was chopped at slow speed for 3 min. The nitrite and ascorbate, dissolved in 5 ml of water, were added at this point. The remaining ice was then added and chopping was continued for an additional 7 min at high speed. The emulsion temperature was approximately 15.5°C at the end of the chopping period.

The emulsion was stuffed into 29-mm cellulose casings manufactured by Union Carbide Co., linked into 13-cm units, and smoked according to a modified procedure as described by Sink and Hsu (19).

The frankfurters were placed in a preheated smokehouse and held for 0.5 h at 55°C with no smoke or humidity and dampers wide open. Heavy smoke was applied for approximately 1 h with dampers 3/4 closed. Smoking was then discontinued and the sausages were heat-processed until an internal temperature of 70°C was obtained to minimize bacterial loads. The total time for smoking and heat processing was approximately 2 h and 15 min. Relative humidity was maintained at 25% throughout the smoking and heat processing phases.

After smoking, the links were rapidly chilled to 30°C by a cold water spray and stored at 4°C until tested.

Color stability tests

The experimental frankfurters were stored at 4°C in transparent, polyethylene, non-vacuum packages continually exposed to 100 fc of fluorescent illumination as measured at the package surface (6). The same side of each package was exposed to the light throughout the storage period. Samples were measured for color changes at 4, 7, 10, 14, 17, and 20 d with a Gardner XL-23 Colorimeter (L, a, and b scales) according to the following procedures. For instrumental surface measurements, either the upper surface exposed to the light or the bottom side away from the light and referred to as the deep surface, frankfurters were first cut in half by making a slice through the midline, longitudinally. Frankfurter halves were then cut to fit a cuvette appropriate for the colorimeter and were placed side by side in the cuvette so that the curved surface of the sample, either upper or deep, would be towards the instrument aperture. A second layer of sample was placed over the first in a similar fashion to block transmission of light through the area adjacent to two frankfurters. Interior color measurements were made on longitudinal slices placed in the cuvette in a similar manner, except the flat inside surface was toward the instrument aperture. Preliminary studies included determination of infinite sample thickness to ensure no transmission of light through the sample. This was determined to be 16 mm.

Color measurements made on commercial poultry and beef franks were done in a similar manner, except no upper surface color measurements were made since formulation and the time of manufacture were not known.

Sensory evaluation and objective shear measurements

Poultry franks for sensory evaluation were placed in 90°C water and allowed to stand for 10 min. They were then cut into 5-cm lengths, placed in red ceramic cups, and kept under warmings lights until served. Samples were served in red ceramic cups and viewed under red light by panelists to mask any color differences.

The sensory panel consisted of 9 graduate students and technicians who were given several training sessions before initiation of the experiment. All testing was done in properly equipped, sensory booths under controlled conditions.

Panelists were given three samples; two numbered samples and a reference. One of the numbered samples was identical to the reference. Using a nine-point degree of difference scale ranging from none to extreme, the panelists were instructed to indicate which of the numbered samples was identical to the reference (in terms of flavor and texture) by checking none of the boxes. The panelists were then required to indicate the degree of difference from the reference of flavor and texture in the remaining sample. Double sessions, morning and afternoon, were conducted each test day.

Objective shear values were determined with a Warner-Batzlizer shearing device (Model 2000) equipped with a 10-lb dynamometer. Each test day, two frankfurts per treatment were sheared three times each, perpendicularly to their length.

**TABLE 1. Chemical composition of the experimental franks and a commercial chicken frankfurter.**

<table>
<thead>
<tr>
<th>Product</th>
<th>pH</th>
<th>Moisture (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Franks with 19 ppm</td>
<td>6.34a</td>
<td>58.95a</td>
<td>17.17a</td>
<td>21.80a</td>
<td>3.43a</td>
</tr>
<tr>
<td>betanin + 0.20% sorbate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Franks with 147 ppm</td>
<td>6.45b</td>
<td>58.80a</td>
<td>17.90a</td>
<td>21.83a</td>
<td>3.29a</td>
</tr>
<tr>
<td>sodium nitrite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial chicken</td>
<td>6.47b</td>
<td>56.12b</td>
<td>14.18b</td>
<td>24.00b</td>
<td>3.96b</td>
</tr>
<tr>
<td>frankfurter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Means within the same column followed by the same letter are not significantly different at the 0.05 level.*

RESULTS AND DISCUSSION

The chemical composition of the experimental franks and a representative commercial chicken frankfurter are shown in Table 1. The significantly lower pH of franks containing betalains versus the other two products may be a function of raw product composition or added sorbate. Regardless, it may be viewed as an advantage since a lower pH extends shelf life during storage and can conceivably contribute to a desirable flavor. Although the effectiveness of potassium sorbate as an antimicrobial agent was not being examined in this study, several workers have shown that it is more effective at lower pH values (3,16,21).

The significantly higher protein levels and significantly lower fat levels for experimental franks versus the commercial product were expected and are a result of product formulation. Most commercial producers use poultry skin, which is relatively high in fat, in their formulations. Barker and Darfler (2) found that the protein content of most commercial poultry franks was in the range of 12-14%. They also reported that the overall acceptability was significantly higher for poultry franks with a protein count of 15 to 18%. Janky et al. (13) reported similar results using meat from Cornish game hens. Consequently, we chose to manufacture a product with higher protein and slightly lower in fat.

Nitrite concentration in the finished experimental product was 147 ppm. It is noteworthy that analysis of the experimental franks revealed a nitrite concentration of 3 ppm.
sodium nitrite. Bremmer and Keeney (5) reported that a beet pigment preparation they were working with contained 8 mg of nitrate per 100 g of beet powder and that this could result in a concentration of less than 1 ppm nitrite in the finished product, if all the nitrate were reduced to nitrite. It is very doubtful that the level of 3 ppm nitrite in the experimental franks was sufficient to affect either color or flavor.

Average Gardner color reflectance values for the experimental frankfurters are shown in Table 2. These data are typical of those recorded throughout the experiment and are presented for the reader’s convenience. For this and subsequent data presentations, color changes are shown graphically as a plot of a/b. Figure 1 shows very clearly that the hue of the surfaces of betalain-containing franks changed very slightly over the storage period while that of the nitrite-containing franks shifted significantly toward the yellow after 7 d. The color of the natural pigment franks was obviously very stable under conditions of this experiment, which is consistent with reports of other workers (1,24). The fading or loss of redness of the nitrite franks was not unexpected as it is well known that the combination of light and oxygen is very damaging to nitrite-based cured meat color (18). In fact, it was evidence presented by previous workers (1,24) that dictated the selection of an oxygen packaging system as being the most rigorous for products colored with betalains.

Color changes for the deep surfaces (undersides) of the experimental and two commercial frankfurters are shown in Fig. 2. It was thought that it might be interesting to look at the color stability of locally purchased commercial frankfurters; however, since we did not know the exact formulation or date of manufacture, we felt it would not be valid to subject them to the same conditions as the test franks. They were, therefore, packaged aerobically and held in a 4°C refrigerator without light, thereby simulating the conditions one might find in a home with an opened package. Also, only the interior and deep surfaces were examined for color change.

Although the commercial samples were slightly redder initially than experimental samples, color stability was similar for all samples throughout the storage period with the exception of the experimental nitrite frankfurter. Loss of redness for this sample undoubtedly resulted because there were small amounts of light reflected to the undersides during storage, whereas the commercial products were stored in the absence of light.

Changes in the interior color of the experimental franks and two commercial products are shown in Fig. 3. Although there were essentially no changes in interior color for any of the frankfurters throughout the storage period, it is interesting to note that the natural pigment frank was identical to the commercial beef and poultry franks while the experimental nitrite-containing frankfurter was not as red. This was probably a function of the reduced myoglobin content of the experimental sample and the fact that most commercial poultry franks are made with mechanically deboned dark meat which includes levels of hemoglobin.

The data relating to color development and stability are consistent with those reported by von Elbe et al. (24), for bologna and summer sausage.

The results of the sensory evaluation are shown in Table 3. There was apparently little difference in flavor and texture between the two experimental frankfurters since panelists were unable to consistently identify a statistically

**TABLE 2.** Average Gardner color reflectance values for frankfurters containing nitrite or betalain pigments as colorants when exposed to light at 100 f.c.

<table>
<thead>
<tr>
<th>Storage time (Days)</th>
<th>Nitrite (147 ppm)</th>
<th>Color source</th>
<th>Betanin (19 ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>1</td>
<td>49.63</td>
<td>8.83</td>
<td>12.80</td>
</tr>
<tr>
<td>4</td>
<td>51.02</td>
<td>8.83</td>
<td>13.35</td>
</tr>
<tr>
<td>7</td>
<td>54.93</td>
<td>4.90</td>
<td>12.06</td>
</tr>
<tr>
<td>10</td>
<td>52.80</td>
<td>5.45</td>
<td>14.05</td>
</tr>
<tr>
<td>14</td>
<td>51.80</td>
<td>5.70</td>
<td>13.60</td>
</tr>
<tr>
<td>17</td>
<td>51.93</td>
<td>4.13</td>
<td>12.90</td>
</tr>
<tr>
<td>20</td>
<td>55.20</td>
<td>4.43</td>
<td>14.40</td>
</tr>
</tbody>
</table>

*Average of six observations.*
significant number of samples as being identical to the reference samples. The absence of nitrite or the presence of sorbate was apparently undetectable by panelists. This is consistent with work by MacNeil and Mast (15), who reported that color and not flavor was the major problem to be overcome should nitrite be eliminated from sausage manufacture. These results are also consistent with those reported by Wasserman and Talley (25), who concluded that the flavor of frankfurters was significantly affected by smoking and only slightly by the presence of nitrite.

Levels of potassium sorbate used in this experiment were such that no undesirable side effects, similar to those reported by other workers (4), were reported by the panelists. In fact, the level was chosen on the basis of work by Paquette et al. (18), who reported that addition of 0.26% potassium sorbate did not affect the sensory qualities of bacon nor were side effects observed. It remains to be seen, however, if this level is sufficient to control microbial growth.

Shear forces were determined to see if the betalain/sorbate combination caused any unusual textural changes in the product. Average force required to shear the samples was 3.14 and 3.28 lb., respectively, for betalain-containing franks and nitrite-containing franks. The difference was not statistically significant (P<0.05). These results are similar to those reported by Whiting and Jenkins (26).

In conclusion, a combination of betalains and potassium sorbate can be used successfully in the manufacture of chicken frankfurters without adversely affecting flavor or texture. In addition, frankfurters containing betalains had the added advantage of greater color stability when exposed to light and oxygen during storage than nitrite frankfurters. This fact would make it feasible to market frankfurters in non-vacuum packages, assuming future work demonstrates the effectiveness of the sorbate on microbiological safety.

ACKNOWLEDGMENTS

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REFERENCES

CHARACTERISTICS OF CHICKEN SAUSAGE


