Enhanced Pork Research
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Enhanced pork is the process of adding non-meat ingredients to fresh pork to improve the eating quality, defined as juiciness, tenderness and flavor, and to extend the microbial and color shelf-life of pork. Enhancement of pork loin chops, roasts, and ribs are a common industry practice and the predominant fresh pork products available at the retail meat case and in the food service industry are enhanced. For retail pork cuts, pork products contain on average 7 to 12% of an injection solution with solutions most often containing water, sodium lactate (NaL), sodium phosphates (NaP), potassium lactate (KL), and/or sodium diacetate (NaD). As researchers, we know a lot about the functionality of these ingredients. A summary of the impact of these ingredients on palatability, flavor shelf-life, microbial shelf-life and microbial safety is presented in Table 1. While it is obvious that these ingredients are extensively used and that their functionalities are known, there is limited information regarding textural changes that occur during the storage of vacuumed-packaged fresh pork loins injected with varying combinations of these non-meat ingredients. Complaints of texture issues include that the enhanced pork is too soft, or that the texture is more like-ham than meat-like. Some research has found that the addition of organic salts, NaL and/or NaP, to beef roasts caused the texture to become more dense when compared to a control (Weber, 2000). Weber (2000) also found that with the addition of organic salts, springiness, cohesiveness, and hardness of beef roasts increased over time. Anwar et al. (2000) found that the texture of beef steaks injected with KL and/or NaD changed from a steak-like bite to a soft/rubbery, processed meat texture during refrigerated storage over a 42 day period. Maca et al. (1997) found that springiness and hardness increased with NaL and/or NaP addition in cooked beef top rounds. While these studies were not conducted using enhanced pork, they indicate that texture changes occur during storage in meat products where non-meat ingredients are used. These texture changes have not been examined in enhanced pork chops and the effect of combination of ingredients on texture changes has not been evaluated. These changes in texture affect the consistency of the final product. As enhanced products have a longer shelf-life, consumers may purchase products at varying times during the life of the product. Changes in texture during shelf-life may induce variation on these products and result in a more inconsistent product. By understanding the combined effect of water, salt, sodium lactate, sodium phosphate, sodium diacetate, and potassium lactate on palatability, texture, color, pH, and water-holding capacity of pork loin chops during vacuum-packaged, refrigerated storage, the pork industry can provide a more consistent enhanced product to consumers.

Therefore, a study is being conducted in my laboratory that was been funded by the National Pork Board using check-off dollars to understand the interaction of water, salt, sodium lactate, sodium phosphates, sodium diacetate, and potassium lactate on pork loin chop palatability. We also are evaluating the pH, color, water-holding capacity and shelf-life stability of injected vacuumed-packaged pork loin chops during storage to provide added information on the effects of combination of these ingredients during storage. These data then can provide industry personnel an understanding of how changing ingredients impacts their final product during storage.
PROJECT DESIGN

Fresh, vacuum-packaged pork loins were obtained from a commercial pork processor for injection. The study was conducted in five segments were two ingredient combinations were studied in each segment. In the first segment or study, the effects of salt (0, 0.25, 0.50, 0.75, 1.00, 1.25, 1.50, 1.75, 2.00%) and sodium phosphate (0, 0.1, 0.2, 0.3 and 0.4%) in the final product were examined. In the second segment, salt level and sodium phosphate were used as defined in the first segment, but a different sodium phosphate was used to understand how sodium phosphate type affects these attributes. In the third segment or study, salt was standardized at .75% and sodium phosphate (0, 0.1, 0.2, 0.3 and 0.4%) and sodium lactate (0, 1, 2, 3 and 4%) differed. In the fourth study, salt was again standardized at .75% and sodium phosphate (0, 0.1, 0.2, 0.3 and 0.4%) and potassium lactate (0, 1, 2, 3 and 4%) were added. In the fifth segment or study, salt and potassium lactate were standardized at .75% and 2%, respectively and sodium phosphate was evaluated at 0, 0.1, 0.2, 0.3 and 0.4% and sodium diacetate were used at 0, 0.05, 0.10, 0.15 and 0.20%.

The standardized injection level was 10% of the fresh weight of the pre-injected loin. Injected pork loins were held 24 h, segmented into 2.54 cm thick pork loin chops, vacuumed packaged in oxygen barrier film (Cryovac Division, WR Grace & CO., Duncan, SC., U.S.A.) and stored at 4 °C. The pork loin chops with a loin were randomly assigned to storage days (0, 7, 14, 21, 28) within a treatment for trained descriptive attribute sensory evaluation. Package purge, color space values of L*, a*, and b* (measured with a Minolta colorimeter), pH, and water-holding capacity (using drip loss method) were determined on 2.54 cm pork loin chops prior to cooking for each treatment on each storage day.

To determine package purge, the vacuume-packaged pork loin chop was weighed prior to opening. The vacuum-package was opened, the pork loin chop removed from the package, and weighed. The vacuum-package of the pork loin chop was weighed without the free juices. Purge weight percentage was determined using the following formula:

\[
\text{Package purge weight, \%} = \left[ 100 - \frac{(\text{Pork loin chop weight})}{(\text{Unopened package weight} - \text{Dry package weight})} \right] \times 100
\]

For color evaluation, the Minolta colorimeter was used to determine the L*, a*, and b* color space values on 3 random locations of the raw pork loin chop lean surface 10 min after removal from the vacuum package (AMSA, 1993). Subjective color was determined by a trained descriptive attribute sensory panel using the 6-point color scale from the National Pork Producers Council.

pH evaluation was preformed in duplicate on the fresh pork loin, brine, and injected pork loin product using a hand-held probe. Water-holding capacity was determined by the drip loss procedure using a modified method of Kauffman (1986). Approximately 20 g muscle sample was weighed, suspended in ham netting within a Whirl-pak ® bag and held at 4 °C for 48 h. Samples then were re-weighed and percentage drip loss determined.

For sensory evaluation ballot development sessions during preliminary studies were used to determine the flavor, aromatics, basic tastes, aftertastes, mouthfeels, and texture attributes. Up to 10 sensory panelists were selected and trained according to Cross et al. (1978) and AMSA (1995). Pork loin chops were cooked on a Farberware Open-Hearth Electric Broiler to an internal temperature of 70 °C. Internal temperature was monitored using type T wire mini-thermocouples placed in the geometric center of each pork loin chop and temperature was monitored by an Omega RD4031 Hybrid Recorder (Omega Engineering Inc., Samford, CT., U.S.A.). Cook yield percentage was determined by the following formula:
Cook yield, % = \[
\frac{(\text{Raw pork loin chop weight} - \text{cooked pork loin chop weight})}{\text{Raw pork loin chop weight}}\] \times 100

Cooking time also was recorded. Pork loin chops were held in the Alto Shaam (750-TH-11, Alto-Shaam, Inc. Milwaukee, WI., U.S.A.) set at 55 °C prior to serving and for no longer then 10 min. Serving preparation included removing .64 cm of the exterior edge of the pork loin chops and cutting the remainder into 1 cm cubes. To minimize positional bias and halo effects, the order of sample presentation was randomized within each sensory session (Larmond 1977). Testing took place in climate controlled, partitioned booths separated from the sample preparation area so that panelists were not be disturbed during evaluation. Two cubes were placed in approved odor-free plastic weigh boats and served to panelist through bread-box style stainless steel domes that separate the food preparation area from the sensory testing area. The separation was necessary to prevent odors and noise in the evaluation booths. Cool incandescent lights with red filters were used to disguise visual differences among the samples. To prevent taste fatigue, expectorant cups were provided and panelist were instructed not to swallow the samples. Distilled, deionized water, unsalted soda crackers, and whole ricotta cheese were used to clean the palate between samples.

The data were analyzed using central composite response surface regression designed to examine two subsequent variables of either salt, sodium phosphate, sodium lactate, potassium lactate, or sodium diacetate. Least squares main effects for treatments also were analyzed using Proc GLM of SAS (1991) and when treatment was significant (P < 0.05), then least squares means were separated using the standard error pdiff procedure (P < 0.05) of SAS (1991).

RESULTS AND DISCUSSION

The study is on-going and at the writing of this paper, the fifth segment was being conducted. Preliminary results from the first study are presented in Figure 1a,b,c for processed meat-like bite after 0, 14 and 28 days of storage, respectively. It is apparent that on day 0 (Figure 1a) only slightly detectable amounts of processed meat-like bite were reported for pork loin chops across salt and sodium phosphates levels. It should be noted that the surface response regression equation was significant (p = 0.0007). As storage day increased to 14 days (Figure 1b), processed meat-like bite increased and the surface response regression equation was significant (p < 0.02). Pork chops containing 0.2% sodium phosphates and higher, and 0.75% to 1.75% salt had more processed meat-like bite than other treatments. These values were between 2.5 and 3.5, not a great change in this texture attribute, but an indication that texture changes were occurring. After 28 days of storage (Figure 1c), the surface response had higher values for processed meat-like bite across all treatments with the highest levels between 5 and 5.5. The references used to train the panel for processed meat-like bite used a non-injected fresh pork loin chop for a 0 in processed meat-like bite; commercially available, flavored, injected pork loins were a 6 to 12 in processed meat-like bite; and Canadian bacon = 13 and Spam was 15 for this attribute. The use of sodium phosphate levels of 0.2 and salt levels of 0.5 and higher resulted in the highest levels of processed meat-like bite after 28 days of storage. While most pork loin chops would not be stored for up to 28 days prior to consumption, these surface response graphs show how changes in either color, water-holding capacity, purge, or sensory attributes will be able to be examined in this study. These surface response curves showed that when sodium phosphate levels greater than 0.2% were used, processed meat-like bite increased. Using this information in combination with the color, purge and other sensory information will allow
product development personnel to make more informed decisions on what levels of salt and sodium phosphates to use in their enhanced pork products.

REFERENCES

Table 1. Summary of ingredient functionality where – = a negative effect, -- = a very negative effect, --- = an extremely negative effect, ~ = a neutral effect, + = a positive effect, ++ = a very positive effect and +++ = an extremely positive effect.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Eating Quality</th>
<th>Flavor</th>
<th>Microbial</th>
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<tr>
<td></td>
<td>Color</td>
<td>Juiciness</td>
<td>Tenderness</td>
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<td>Water</td>
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<td>++</td>
<td>++</td>
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<tr>
<td>Sodium phosphates</td>
<td>+</td>
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<td>++</td>
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<td>Salt</td>
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<td>Sodium lactate</td>
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<td>Potassium lactate</td>
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<td>Sodium diacetate</td>
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Figure 1a. Surface response curve for processed meat-like bite of enhanced pork loin chops containing from 0 to 2% salt and 0 to 0.4% sodium phosphates after 0 days of storage.

Figure 1b. Surface response curve for processed meat-like bite of enhanced pork loin chops containing from 0 to 2% salt and 0 to 0.4% sodium phosphates after 14 days of storage.
Figure 1c. Surface response curve for processed meat-like bite of enhanced pork loin chops containing from 0 to 2% salt and 0 to 0.4% sodium phosphates after 28 days of storage
Dr. Rhonda Miller

Dr. Rhonda Miller is a Professor in the Meat Science Section of the Department of Animal Science at Texas A & M University and she holds appointments on the Faculty of Food Science and Technology and the Graduate Faculty of Nutrition. She earned her bachelor degree, master’s degree and doctorate at Colorado State University and conducted her doctorate research in cooperation with the U.S. Department of Agriculture, Agricultural Research Service in Clay Center, Nebraska. Her duties include teaching undergraduate and graduate courses in meat science and conducting research on the quality, quantity, safety and usefulness of meat and meat products. She has responsibility for the Sensory Testing Facility within the department where a wide variety of meat and food products are evaluated for flavor, texture and palatability. Dr. Miller brings the unique combination of industry application to her responsibilities, as she was director of research and development at Monfort, Inc., where she developed over 300 new meat products for their further processed division.