BENCHMARKING VALUE IN THE PORK SUPPLY CHAIN: PROCESSING CHARACTERISTICS OF HAMS MANUFACTURED FROM DIFFERENT QUALITY RAW MATERIALS

Person, R.C.[1], Mueller, S.L.[1], Baird, B.E.[1], McKenna, D.R.[1], Griffin, D.B.[1], McKeith, F.K.[2], Scanga, J.A.[3], Belk, K.E.[3], and Savell, J.W.[1]

[1]Department of Animal Science, 2471 TAMU, Texas A&M University, College Station, TX 77843-2471, USA
[2]Department of Animal Science, University of Illinois, Urbana, IL 61801, USA
[3]Department of Animal Sciences, Colorado State University, Fort Collins, CO 80523, USA

Background

In 1992, economic losses associated with low pork quality were estimated to be only 3% of the unrealized revenue lost from nonconformities in carcass quality. Today, low pork quality accounts for nearly 24% of the unrealized revenue lost from nonconformities in carcass quality, with most of those losses associated with pale, soft, and exudative (PSE) pork, and muscles containing low water-holding properties (Stetzer and McKeith, 2003). The 2003 estimate of PSE incidence was 15.5% (Stetzer and McKeith, 2003) compared to 10.2% reported for 1992 by Cannon *et al.* (1996).

It is often difficult to define the extent of PSE within a muscle; in many cases, muscles will exhibit varying degrees of PSE tissue. For example, the medial portion of a ham muscle may be entirely PSE, whereas the lateral portion of that same ham muscle may appear normal. The weight of hams increased 19% compared to 1992 (Stetzer and McKeith, 2003), making the aforementioned scenario more likely to occur because as the mass of a ham increases, it becomes more difficult to chill rapidly.

The ham processing industry uses a majority of the ham muscles produced by the packing sector, however, little research has been conducted to look at the production inefficiencies, such as decreased processing yields, increased rework, and decreased consumer demand from inferior products, that result from using raw materials that contain muscles with poor color and water-holding properties.

Objectives

The purpose of the study was to determine the impact of different quality raw materials on the processing characteristics of hams.

Materials and methods

Pork leg (fresh ham), insides (IMPS #402F; NAMP, 1997; USDA, 1997), containing both *M. semimembranosus* and *M. gracilis*, were characterized as having a low, intermediate or high incidence of pale, soft, and exudative (PSE) muscle tissue according to NPB (1999) guidelines and were sorted accordingly. Objective color measures (CIE L*-, a*-, and b*-values) and pH values were collected at the time of sorting using a Hunter MiniScan XE (HunterLab Associates, Inc., Reston, VA) and a handheld pH meter (pHStar, SFK Technologies, Inc, Cedar Rapids, IA). Objective measures of color and pH (n = 100 per group) were collected in two locations on the medial side of selected muscles. Groups also were characterized for the percentage of PSE in the muscle tissue by removing and collecting weights on PSE portions in 45 kg samples from each group. Muscles in the "Low PSE" group contained < 5% PSE tissue, whereas muscles in the "Intermediate PSE" group ranged between 20% to 30% PSE, and muscles from the "High PSE" group ranged between 40% to 60% PSE. Approximately 3,000 kg of raw materials were collected for each group and an additional 3,000 kg of commodity muscles were collected to serve as a control. All raw materials were shipped by refrigerated carrier to a commercial ham processing facility.

Upon arrival, raw materials were unloaded and purge was collected and weighed before it was reintroduced into the process. Muscles were injected with a curing solution, macerated, tumbled, formed, and cooked using normal procedures within the commercial processing facility to produce a 10.2 × 15.2 cm ham, water added product. After cooking, ham logs were chilled and stored for approximately 3 weeks before slicing. Ham logs were crust-frozen, sliced, and packaged in 454 g packages. Hams slices were evaluated for defects after slicing, which were classified as normal rework (i.e., small tears, end pieces, or other minor imperfections) or PSE rework (i.e., severe product defects associated with low functionality muscle). Ham slices were evaluated for color uniformity during packaging. Slices containing nominal variations in color were classified as normal or no defect, those containing slight contrasts in color uniformity or small pale spots were classified as having minor defects, and those exhibiting substantial contrasts in color uniformity, large pale spots or small pockets were considered to have major defects. Packages (n = 100 per group) also were evaluated for objective color measures (CIE L*-, a*-, and b*-values) using a Hunter MiniScan XE (HunterLab Associates, Inc., Reston, VA).

Packaged, finished ham products from each group were selected randomly and shipped to Texas A&M University. Upon arrival, ham packages were placed in a 2°C cooler for storage. Packages of ham (n = 17 per group) were selected after 15-, 30-, 45-, 60- or 75-days of storage, objective color measures (CIE L*-, a*-, and b*-values) were collected as previously described, and the weight of purge was measured from each package. On day 45, ham slices also were evaluated for consumer sensory evaluations. Consumer evaluations were conducted at the sensory testing facility at Texas A&M University and participants were recruited from the faculty, students, and staff. Participants were asked to rate samples from each ham group for flavor intensity, overall like of flavor, visual appeal, and color. Participants were placed in individual panelist booths and given samples one at a time in random order. Ballots consisted of an 8-point scale for each trait evaluated (1 = extremely dislike; 8 = extremely like). In addition, purchase intent was determined by asking participants to select three packages of ham from an assortment of 12 packages. All groups of hams were represented equally and their arrangement was randomized. Packages that participants selected and the order that they selected packages was recorded.

Data were analyzed using SAS (SAS Institute, Cary, NC). Descriptive statistics and frequency distributions were generated using the PROC Means and PROC Freq procedures, respectively. Analysis of variance was performed using the PROC GLM procedure with product quality group tested as the main effect. When main effects were determined to be significant ($P < 0.05$), least squares means were generated and separated using a pairwise t-test (pdiff option).

Results and discussion

Sorting was effective in stratifying quality groups as the group containing the lowest amount of PSE had the highest mean pH value (6.14) and the group containing the most PSE muscle had the lowest mean pH value (5.62). Furthermore, pH differences between groups were incremental, with approximately 0.2 units separating each group. Kauffman *et al.* (1978) found that hams classified as “PSE” had a pH of 5.5, whereas “normal” hams had a pH of 5.9 and dark, firm, and dry hams had a pH of 6.3 (all as measured in *M. gluteus medius*).

Differences in objective color measures between raw material quality groups were as expected. The “Low PSE” group had the lowest L*-values and b*-values and the highest a*-values, whereas the “High PSE” group had the highest L*-values and b*-values and the lowest a*-values. Color and pH values for the control group were situated between the values recorded for the “Low PSE” group and the “Intermediate PSE” group. We estimated that the incidence of PSE was less than 5% and 20 to 30% in the “Low PSE” and “Intermediate PSE” groups, respectively. Because color and pH data indicate that raw materials in the control group fit between those groups, we expect that the control group contained 10 to 15% PSE muscle, which is similar to incidence rates reported by Stetzer and McKeith (2003), Cannon *et al.* (1995) and Kauffman *et al.* (1992).

Stratification of L*- and a*- values for boneless hams from different quality groups was identical to stratification of L*- and a*-values observed in raw materials. Hams manufactured from the control group had the lowest b*-values, which was unexpected because raw material data indicated that the “Low PSE” group had the lowest b*-values. This finding is probably not important because numerical differences in b*-values were extremely small.

Hams manufactured from the “Low PSE” group had the lowest purge loss, followed by hams from the control group. No difference in purge loss was observed between hams manufactured from the

"Intermediate PSE" group and the "High PSE" group. O'Neill *et al.* (2003) reported that drip loss in cooked hams manufactured from PSE pork was four times greater than hams manufactured from normal pork. Differences observed in this study were not as severe as those described by O'Neill *et al.* (2003), however, this may be because drip and purge loss were measured using different methods. The discrepancy in purge loss differences between hams manufactured from the different quality groups may partially be explained by the extent of purge loss in the raw materials before processing. Control and "Low PSE" raw materials possessed the ability to hold water more effectively as they had 0.7% and 0.6% purge loss, respectively, in storage before processing. In contrast, raw materials from the "Intermediate PSE" group had 1.0% purge loss and raw materials from the "High PSE" group had 2.6% purge loss indicating much lower water-holding capacity. This is not unexpected as Offer (1991) previously described lower water-holding capacities in muscle containing greater denaturation. After processing, it was not expected that hams manufactured from the "Intermediate PSE" and "High PSE" groups would have similar purge loss percentages. We expected the "High PSE" group would have the greatest purge loss because greater quantities of PSE muscle should have less functional protein and lower water-holding capacities.

Boneless hams were sliced, sorted into 454 g samples, and vacuum-packaged. Before packaging, ham groups were assessed for quality defects that would be considered "normal rework" (i.e., ends and pieces, small pockets, etc.) or "PSE-outs" (i.e., severe holes caused by a lack of functional protein). Boneless hams manufactured from the "Low PSE" group had the lowest incidence of quality defects and lowest total yield loss. Incidence rates for "PSE-outs" and total yield loss were three times greater in control product than were observed in hams manufactured from the "Low PSE" group. Incidence rates for "PSE-outs" in the "Intermediate PSE" and 'High PSE" groups were 5 to 6 times greater than those observed in the "Low PSE" group. Moreover, total yield losses observed in the "Intermediate PSE" and "High PSE" groups were four to five times greater than the yield losses observed in the "Low PSE" group. O'Neill et al (2003) reported the importance of water retention and cohesiveness in slicing. As greater percentages of PSE in the raw materials were incorporated into the ham formulations, water retention and cohesiveness would be reduced because of the incorporation of less functional protein. Surprisingly, incidence rates for "normal rework," and "PSE-outs," and thus total yield losses were greatest in hams manufactured from the "Intermediate PSE" group. We expected incremental increases in slicing defects as the percentage of PSE pork included in the hams increased; clearly this was not the case. Raw materials in the "Intermediate PSE" group may have been the most heterogeneous and therefore presented the greatest challenge of merging "functional protein" with "non-functional" protein (i.e., PSE muscle).

After packaging, finished hams (after "normal rework" and "PSE-outs" were sorted out) were assessed for minor and major appearance defects. Generally, percentage of defects increased incrementally with increasing levels of PSE product in the raw materials. Hams manufactured from the "Low-PSE" group had the highest percentage of packages with no defects and virtually no packages with major defects. In contrast, only half of all packages containing ham manufactured from the "High PSE" group had no defects, whereas 43.1% contained a minor defect.

Demographic data provided by consumers indicated that nearly 64% of participants were between the ages of 20 and 39 and approximately 45% were male and 55% were female. Consumers indicated no preference for "flavor" or "overall like" of ham from any of the quality groups. Consumers gave the lowest color ratings for ham manufactured from the "High PSE" group, but gave similar color ratings for hams manufactured from the other quality groups. Ratings for visual appeal were similar to ratings for color as consumers gave the lowest ratings for ham from the "High PSE" group, but did not differentiate ham manufactured from the other quality groups. Purchase intent for packages of ham manufactured from the different quality groups showed even greater consumer discrimination against hams manufactured from different quality groups than color or visual appeal responses. Overall selection showed that nearly 60% of consumer selections were packages of ham manufactured from the "Low PSE" quality group with 64% of consumers making one of those packages their first selection. Packages of ham manufactured from the "Intermediate PSE" quality group had the second most frequent selection, whereas packages of ham manufactured from the control group and the "High PSE" quality group were selected the least frequently. We expected selection frequencies for packages of ham from the control group and "Intermediate PSE" group to have similar selection responses, however, clearly this was not the case. It is unclear why consumers discriminated against ham packages from the control group. Consumer data showed that color and visual appeal responses for ham from control, "Low PSE," and "High PSE" products were similar.

It is interesting to note that when consumers were asked to make independent ratings of hams, they gave responses that indicated very little difference in the color and visual properties of the hams manufactured from the various quality groups. Nonetheless, when consumers were in a situation that they could directly compare packages of ham (i.e., similar to a retail environment), there was distinct discrimination against hams manufactured with greater amounts of PSE in the raw materials. Whether or not consumers would be willing to spend more for hams manufactured with low quantities of PSE will require further research.

Conclusions

Sorting pork raw materials according to quality parameters impacts the processing yields and consumer appeal of products manufactured from those raw materials. For boneless ham manufacturing, processing yields and defects were minimized when muscles containing high levels of PSE tissue were eliminated. Further research is needed to determine the optimal ratio of allowable PSE product in formulation that enables processors to maximize consumer appeal with the economic realities of sorting out PSE pork.

References

Cannon, J.E., Morgan, J.B., McKeith, F.K., Smith, G.C., Sonka, S., Heavner, J., & Meeker, D.L. 1995. Pork chain quality audit survey: Quantification of pork quality characteristics. J. Muscle Foods 7:29-44.

Kauffman, R.G., Cassens, R.G., Scherer, A., & Meeker, D.L. 1992. *Variations in pork quality: history, definition, extent, and resolution*. National Pork Board, Des Moines, IA.

Kauffman, R.G., Wachholz, D., Henderson, D., & Lochner, J.V. 1978. Shrinkage of PSE, normal, and DFD hams during transit and processing. J. Anim. Sci. 46:1236-1240.

NAMP. 1997. *The meat buyers guide.* North American Meat Processors Association, Reston, VA.

NPB. 1999. *NPB official color and marbling standards*. National Pork Board, Des Moines, IA.

O'Neill, D.J., Lynch, P.B., Troy, D.J., Buckley, D.J., & Kerry, J.P. 2003. Effects of PSE on the quality of cooked hams. Meat Sci. 64:113-118.

Offer, G.E. 1991. Modeling of the formation of pale, soft, and exudative meat: effects of chilling regime and rate and extent of glycolysis. Meat Sci. 30:157-184.

Stetzer, A.J. and McKeith, F.K. 2003. Benchmarking value in the pork supply chain: Quantitative strategies and opportunities to improve quality: Phase I. Benchmarking value in the pork supply chain: Quantitative strategies and opportunities to improve quality. American Meat Science Association, Savoy, IL, USA.

USDA. 1997. *Institutional meat purchase specifications for fresh pork products*. USDA, Agricultural Marketing Service, Washington, DC.