

The Effects of Freezing on the Processing Characteristics and Palatability Attributes of Fresh Pork Legs¹

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Introduction

Fresh pork legs are often stored for several months prior to processing in anticipation of peak consumer demand, which usually occurs during the holiday season. Traditionally, pork legs are frozen and stored in large batches that usually weigh 2000 pounds. If the pork legs could be de-boned prior to freezing and storage, considerable storage space could be saved, decreasing storage and cooling costs.

It is well documented that pork correctly packaged and held at a constant freezing temperature is of acceptable quality after six months of storage. Jeremiah (1980) demonstrated that fresh pork leg roast could be stored 196 days without loss of palatability attributes if protective wraps were used. However, problems could arise because of tissue disturbance caused by fat and bone removal. Buckley et al. (1989) stated that when storing ground pork patties, the reduction of particle size enhanced the rate of oxidative rancidity. Korschger and Baldwin (1972) found that freezing the partially cooked semitendinosus and semimembranosus muscles of

pork for six months did not have an adverse effect on palatability.

A study by Callow (1952), which observed pork stored frozen for long periods of time, showed an increase in drip loss that was attributed to ice crystal formation and protein denaturation. Goldner et al. (1974) found that frozen pork loins had a greater drip loss than fresh pork loins, and Ashby and James (1973) showed a freezer shrink after thawing of .75% to .82% on pork loins, depending on the protective packaging used during storage.

The objective of this study was to ascertain if de-boning and vacuum packaging of fresh hams for frozen storage had any effect on the processing qualities and oxidative rancidity of the cured ham as compared to the traditional method of freezing and storing of fresh bone-in hams.

Experimental Procedure

Seventy-two fresh pork legs were randomly assigned to one of two processing methods where 1)

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the pork leg was completely de-boned and all external fat was removed, vacuum packaged, boxed and frozen at -18°F or 2) the pork leg was left intact and was bagged in a Mobil Chemical Poultry H. heavy bag, boxed and frozen at -18°F. Pork legs were stored frozen for 124 days at which time they were thawed at 40°F four days prior to processing. Upon thawing, the bone-in pork legs were de-boned and denuded as were the pork legs in processing method 1.

Prior to pumping, a .25 inch slice was taken for 2-thiobarbituric acid method analysis, or TBA (Lipid oxidation was by the 2-thiobarbituric acid method analysis). The semimembranosus and biceps femoris were pumped to 20% of green weight, hand massaged for two minutes, and stuffed into a 4-inch-diameter smoke-impregnated fibrous casing. The pork leg muscles were weighed before pumping, after pumping, after stuffing into the casing, at one hour (to account for drip loss), before cooking and after thermal processing. After stuffing, the injected pork legs were allowed to equilibrate overnight at 40°F and then cooked to an internal temperature of 150°F. At 24 hours after cooking, the hams were sliced and vacuum packaged to obtain samples for TBA analysis and sensory and visual appraisal. Slices for sensory panel color and visual evaluations were .25 inches thick while the slices for TBA analysis were .1 inches thick. TBA values were measured at weeks 1, 4 and 7 of retail display storage at 40°F. Ham slices were visually evaluated weekly starting at week 0 through week 5 of storage at 40°F.

Ham slices were evaluated daily by a trained, five-member panel during five days of storage in a retail meat case (39-42°F). Samples were displayed under GE "natural" fluorescent lighting. Ham slices were evaluated for: muscle color (8 = very light pink; 1 = very dark pink), muscle discoloration (8 = no discoloration; 1 = 100% discoloration) color uniformity (6 = uniform color, 1 = extremely uneven color) and purge (6 = non detected; 1 = excessive purge).

For sensory evaluation, the ham slices were evaluated by an 11-member, trained panel for: juiciness (8 = extremely juicy; 1 = extremely dry), flavor intensity (8 = extremely intense; 1 = extremely bland), overall tenderness (8 = extremely tender; 1 =

extremely tough), saltiness (8 = none detected; 1 = extremely salty) and off-flavor (6 = none detected; 1 = extreme off-flavor). Samples were randomly assigned to a sensory evaluation period.

The experimental design was a split plot for the freezing treatment. Data were analyzed using the general linear models procedures of SAS (SAS, 1985). Interactions within treatment groups, least square means and appropriate standard errors are presented.

Results and Discussion

Fresh pork legs stored intact (de-boned after freezing and thawing) resulted in cured ham slices that had greater cooking loss and higher salt content than slices from fresh pork legs frozen and stored boneless and vacuum packaged (Table 1).

Table 2 shows that de-boning the fresh pork legs before freezing significantly increased the percent of moisture lost upon thawing. This could be explained by the destruction of the cell wall by ice crystal formation and the de-boning procedure. There was a greater percent of brine taken up by the muscles from the fresh pork legs that had been frozen after de-boning. Muscles from fresh pork legs de-boned post-freezing lost a higher percent of their weight in the 24-hour equilibrium period than those hams boned pre-freezing. This might suggest that boning prior to freezing as compared to boning after freezing had no influence on the protein's ability to bind water.

Table 3 shows that de-boning before freezing had little effect on any of the retail storage characteristics. There was, however, a significant difference ($P < .05$) in the purge loss for week two between the two storage treatment groups. Although this difference was statistically significant, the difference was not practically different. The slices from fresh hams stored de-boned and vacuum packaged had lower TBA values than ham slices from fresh hams frozen bone-in and not vacuum packaged. Vacuum packaging could account for the difference in TBA values especially before pumping, where the differences were even greater. TBA scores of cured ham slices stored for seven weeks showed no difference as time of storage increased, but there was a significant difference between boning treatments.

Cured ham slices from hams de-boned before freezing had a significantly ($P < .05$) lower TBA scores than did the cured ham slices from hams boned after frozen storage. Nevertheless, the scores were so low that the typical consumer could not detect any off-flavor. This assumption is supported by sensory evaluation, which detected no off-flavors for any of the ham slices.

Fresh ham, frozen bone-in, produced cured ham slices that were scored higher in juiciness, tenderness and saltiness by sensory panelists than were ham slices from fresh hams boned and denuded prior to freezing (Table 4). This was in agreement with the data in Table 1, which shows that freezing hams bone-in resulted in cured slices that contained a higher percent salt.

Summary

A study was conducted to determine the effects of freezing fresh pork legs whole vs. deboned on the processing characteristics and the palatability attributes of ham slices. Within this study, half of the pork legs were de-boned before freezing, as opposed to bone-in storage, in order to determine the effect of storage method on the above traits. De-boning pork legs before frozen storage did result in some changes in curing characteristics and taste of the ham. Finally, although pork legs frozen bone-in had more desirable palatability scores and proximate composition, the changes were of no practical difference and therefore boneless storage of fresh hams may be a viable method.

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Table 1. Means and Standard Errors (Se) for Proximate Analyses of Restructured Ham Slices

| Proximate composition, % | | | | |
|---|----------|-------------------|--------------------|------|
| Effects | | Salt | Moisture | Fat |
| Storage treatment | | | | |
| | Boneless | 2.73 ^A | 68.21 ^A | 4.06 |
| | Bone-in | 2.99 ^B | 69.38 ^B | 3.70 |
| | SE | 0.08 | 0.15 | 0.08 |
| ^{A,B} Means in a column within a main effect having different superscripts are different (P < .05) | | | | |

Table 2. Effect of Boning Treatment on Curing Characteristics of Fresh Pork Hams

| Effects | | Thaw Loss, % | Pump, % | Equilibrated Pump, % | Cook Loss, % | Chill Loss, % |
|--|----------|-------------------|--------------------|-------------------------|-----------------|------------------|
| Storage treatment | | | | | | |
| | Boneless | 8.45 ^X | 22.52 ^A | 17.30 | 14.17 | 2.20 |
| | Bone-in | 4.47 ^Y | 20.78 ^B | 18.10 | 14.40 | 2.19 |
| | SE | 0.00 | 0.55 | 0.50 | 0.41 | 0.14 |
| ^{A, B} Means in a column within a main effect having different superscripts are different (P < .05) | | | | | | |
| ^{X, Y} Means in a column within a main effect having different superscripts are different (P < .01) | | | | | | |

Table 3. Effect of Boning Treatment on Retail Display Characteristics, Development of Rancidity and Color Stability

| Trait | Storage | Storage Treatment | | |
|-------------------------------|---------|-------------------|------------------|-----|
| | Weeks | Boneless | Bone-in | SE |
| Color uniformity ^A | 1 | 3.8 | 3.8 | .10 |
| | 2 | 3.7 | 3.9 | .12 |
| | 3 | 3.7 | 3.7 | .11 |
| | 4 | 3.4 | 3.5 | .11 |
| | 5 | 3.4 | 3.4 | .11 |
| Ham color ^B | 1 | 5.6 | 5.6 | .11 |
| | 2 | 5.5 | 5.3 | .11 |
| | 3 | 5.4 | 5.4 | .13 |
| | 4 | 5.3 | 5.2 | .13 |
| | 5 | 5.2 | 5.2 | .11 |
| Discoloration ^C | 1 | 7.7 | 7.7 | .03 |
| | 2 | 7.6 | 7.6 | .06 |
| | 3 | 7.3 | 7.4 | .07 |
| | 4 | 7.0 | 7.2 | .07 |
| | 5 | 6.8 | 6.9 | .09 |
| Purge score ^D | 1 | 5.9 | 5.9 | .02 |
| | 2 | 5.7 | 5.8 | .03 |
| | 3 | 5.8 | 5.8 | .03 |
| | 4 | 5.7 | 5.7 | .05 |
| | 5 | 5.7 | 5.6 | .05 |
| TBA value ^E | 0 | .17 ^A | .70 ^B | |
| | 1 | .09 ^A | .12 ^B | .01 |
| | 4 | .09 ^A | .12 ^B | .01 |
| | 7 | .09 ^A | .13 ^B | .01 |

^A Color uniformity scores: 6 = uniform color; 1 = extremely uneven color.
^B Ham color scores: 8 = very light pink; 1 = very dark pink.
^C Discoloration scores: 8 = no discoloration; 1 = 100% discoloration.
^D Purge amount in retail package: 6 = no purge; 1 = excessive purge.
^E TBA expressed as MG Malonaldehyde/ KG meat.

Table 4. Sensory Evaluation Means and Standard Errors (Se) of Ham Slices

| Effect | Level | Sensory Panel Evaluation ^C | | | | |
|-------------------|----------|---------------------------------------|------------------|------------------|------------------|------------|
| | | Juiciness | Flavor intensity | Tenderness | Saltiness | Off-flavor |
| Storage treatment | Boneless | 4.9 ^A | 5.4 | 5.6 ^A | 4.4 ^A | 5.8 |
| | Bone-in | 5.8 ^B | 5.8 | 6.1 ^B | 3.8 ^B | 5.7 |
| | SE | .11 | .08 | .09 | .10 | .03 |

^{A, B} Means in a column having different superscripts are different (P < .05).
^C Juiciness, flavor intensity, tenderness, and saltiness were evaluate using 8-point scales where 8 = extremely juicy, intense flavor, tender or no salty taste, respectively, and 1 = extremely dry, bland, tough or salty. Off-flavor scores were 6 = no off-flavor detected and 1 = extreme off-flavor. Evaluations were from chilled ham pieces sized 1/2 x 1/2 x 1 inch.