

## **Effects of Wet Aging and Temperature on Warner-Bratzler Shear Force, Sensory Characteristics, and Microbial Shelf-Life of Pork Loin Chops**

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### **ABSTRACT**

**Twelve paired bone-in loins (IMPS# 410) were used to investigate effects of wet aging and temperature on Warner-Bratzler shear force (WBSF), cook loss, sensory characteristics, and microbial shelf-life. Loin chops (n = 120) were assigned randomly to two temperature groups (1.1 °C and 3.3 °C) and wet aged 0, 3, 6, 9, and 12 days. Higher WBSF values were reported for days 0, 3, and 9 (P < 0.05) than days 6 and 12. Microbial growth increased as days of aging increased. Juiciness, initial tenderness, and flavor increased as days of aging increased. These findings suggest wet aging pork loin chops can lead to improvements in product quality for the consumer.**

**KEY WORDS:** shear force, wet aging, microbial, pork

### **INTRODUCTION**

Addressing the problem of inconsistent meat palatability and the requirements for food safety are of great importance to the meat industry. Consumer dissatisfaction due to sensory attributes will be solved when unacceptable variations in meat sensory characteristics are minimized. Food safety will be improved when shelf-life attributes are identified and interventions are in place to prevent adulteration of products and microbial growth. Pork is the most widely consumed protein at 40% worldwide (USDA 2008) and is the third most popular in the United States. Pork producers struggle with in providing consumers with a uniform, highly palatable and wholesome product. Tenderness has been identified as one of the more influential attributes in determining consumer satisfaction of pork retail products (Kannan et al. 2002). Identifying consumer perceptions of tenderness and juiciness as well as establishing methods to assure wholesome products are important attributes for producers, consumers, and the scientific community.

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Beef products can undergo wet or dry aging to increase overall palatability. In the beef industry, aging has provided producers with an alternative for marketing their products based upon quality and uniformity. Aged beef products tend to have a more pungent and unique flavor profile. Unlike beef, the pork industry has not achieved the same popularity of dry or wet aging techniques. Methods utilized for aging, duration of aging periods, or temperatures during the aging periods have yet to be explored in the pork industry due to production costs, operational efficiencies, and variation in the chemical and physical properties of pork. Rancidity in pork products may occur more often due to fat types and diet sources of fats causing difficulties for aging pork without exceeding current industry standards (Koochmariaie 1992).

Unlike dry aging, controlled humidity and air velocity are not required for proper wet aging. Aging in vacuum packages substantially reduces weight losses during aging by up to 50% and reduces trim losses on the exterior of cut surfaces of beef products (Parrish et al. 1969). The rate of postmortem meat tenderization differs among species. According to Dransfield (1994) and Koochmariaie (1995), 80% of tenderization occurs in about five days for pork and 14 days for beef in order to reach the same degrees of tenderization. Differences in meat tenderness are related to differences in amounts of connective tissue within the muscles, formation of collagen cross-linkages in connective tissue components of muscles, contractile states of the myofibrils in the muscles when rigor bonds are formed, amounts and distribution of marbling within muscles, and extent of postmortem muscle proteolysis that occurs in muscles during aging processes (Smith et al. 1978).

However, pork quality can be enhanced through further research regarding maximizing shelf life and aging effects and how these traits impact palatability. This will require determining processes that affect meat palatability and perhaps more importantly adopting additional methods to assure tenderness, juiciness, and acceptable shelf life of pork products. Therefore, the objective of this study is to determine the impact of storage temperature and wet aging on tenderness, sensory characteristics, and shelf-life of pork loin chops.

## MATERIALS & METHODS

The study was conducted in the Tarleton State University Meat Laboratory. This abattoir is a Texas State Department of Health inspected meat facility. Current Hazard Analysis and Critical Control Point procedures were in place at all times. The temperatures of the coolers used to age the products were monitored and logged continuously (hourly and daily) by the Tarleton State University Facilities Control Center. Monitoring prevented any fluctuation in the temperatures of the cooler being utilized as well as monitoring the defrost cycles of the units.

**Product Selection.** Twelve paired pork full loins (IMPS #410) as defined by the Institutional Meat Purchasing Specifications (IMPS) ( $n = 24$ ) were obtained from a commercial pork slaughter and meat distribution facility. At 48 hours postmortem, carcasses were tracked during fabrication into bone-in full loins (IMPS #410) and vacuum packaged. Seventy-two hours postmortem the pork loins were shipped to and received by Tarleton State University Meat Science Laboratory. Pork loins were immediately identified and randomly selected for treatment groups. Product was selected from pork carcasses ranging in weights from 55 kg to 80 kg. Bone-in pork loins (IMPS

#410) were randomly assigned to one of two aging temperatures (1.1 °C and 3.3 °C) and five aging times (0, 3, 6, 9, and 12d) for each pork chop from the corresponding pork loins.

**Loin Fabrication.** Seventy-two hours post-mortem bone-in pork loins were removed from their vacuum packages and blotted dry with paper towels. Again, loins were randomly assigned to one of two aging temperatures (1.1 °C and 3.3 °C) and then fabricated. Pork loins were cut perpendicular to the thoracic bones 5 cm posterior to the blade end using a band saw (Biro, Model #3334; The Biro® MFG Co., OH)

Bone-in center loin chops (2.54 cm thick) were cut and scraped free of bone residue. Chops were further randomly assigned within each temperature (Group A: 1.1 °C and Group B: 3.3 °C) and to one of five storage days (0, 3, 6, 9, and 12d) for aging. Aging periods began following the fabrication of the pork bone-in full loins into pork loin chops (72 hours postmortem). Chops were identified by temperature and storage period, vacuum packaged individually in a 3 mil nylon/polyethylene construction bags (WinPAK, Midwestern Research and Supply Inc., KS) using a table top vacuum packager (Multivac, Model #C200; Multivac Inc., Kansas City, MO).

**Aging Treatments.** Storage temperatures were monitored (Johnson Control System) using a data logging software by the Tarleton State University Control Center. Temperatures were recorded hourly with defrost periods occurring four times each day (0800, 1200, 1700, and 2400). Pork chops were assigned to and stored at 1.1 °C and 3.3 °C for one of the following periods: 0, 3, 6, 9, or 12 days post fabrication and packaging. The aging times used in this study were selected to represent short, intermediate, and long storage times likely to be found in commercial practice. The short aging time was selected to be well within aging times observed at a retail market.

**Warner-Bratzler Shear Force Measurements.** An industry standard Warner-Bratzler shear machine made by G-R Manufacturing Company in Manhattan, KS, was utilized in all mechanical tenderness tests. Warner-Bratzler testing and sensory panelists were trained and selected according to the recommended protocol (AMSA 1995).

At the conclusion of the aging periods, the pork loin chops were frozen at -20 °C until instrumental tenderness was measured. Prior to cooking, pork loin chops were thawed for 24 hours at 4.44 °C. Chops were removed from their vacuum packages, blotted dry, and weighed. Weights were recorded pre- and post-cooking (Accu-Weigh, Model #SPC-5005, Yamato). Chops were grilled on an open-face electric pre-heated griddle to 176 °C and to an internal temperature of 70 °C. The internal chop temperatures were monitored during the cooking process using a thermocouple inserted into the geometric center of each chop and recorded using a digital thermometer (Econo Temp™ 32311-K, Cooper-Atkins Corp., CT), (AMSA 1995). During cooking, each chop was turned every four minutes until the desired internal temperature had been achieved. Chops were placed in a cooler at 2 °C and allowed to chill for a 24-hour period until internal temperatures reached between 2 °C and 5 °C. After chilling for 24 hours, a coring device was used to remove three cores from each chop to be used for the Warner-Bratzler shear test. The medial, lateral, and dorsal section cores were sheared perpendicular to the long axis of the core with a Warner-Bratzler shear force unit. Shearing of each core was performed by a V-shaped cutting blade with a triangular aperture of 60° at a velocity of 200 mm/min. Maximum force values were obtained to

generate an average value per sample, indicating the maximum mechanical tenderness value. Peak shear force values were recorded and averaged for each chop.

**Microbial Sampling.** All microbiological products used within the study were purchased through 3M™ Microbiology, St. Paul, MN, so as to guarantee consistency. Sample collections and platings were performed according to 3M™ Microbiology Petrifilm™ recommendations. The same technician conducted all microbiological testing and recorded all results. This provided consistency and uniformity in the quality of the data collected.

Microbial sampling was conducted on one pork chop from each aging treatment (0, 3, 6, 9, and 12 days post fabrication) prior to freezing at -20 °C and from each temperature treatment group. Microbial sampling provided the data for the study of the shelf-life of temperature controlled wet aged center pork loins. Microbial sampling was conducted using a USDA-FSIS sampling kit for meat and poultry (3M™ Microbiology, St. Paul, MN). Pork chops were sampled by swabbing a sterile sponge across both sides of the chop. Upon completion of the sample collection, the samples were pumped with a stomacher for 30 seconds at 230 RPM (Stomacher® 400 Circulator, Seward). Plating was performed by lifting the top film and holding the pipette perpendicular to the surface. The researcher dispensed 1 mL of the obtained sample suspension into the center of the bottom film. The samples were analyzed using the total aerobic plate count method (APC). This was performed using standard serial dilutions and plate counting methods. Tenfold serial dilutions prepared in 0.1% peptone water were plated on aerobic petrifilms (3M™). A vortex (VWR Analog Vortex Mixer, Henry Troemner LLC.) was used to homogenize dilutions. At a slow rate, the lab technician rolled the top film down on the plate to prevent air bubbles. A plastic spreader was used on the plate with the flat side down in the center of the plate. The lab technician pressed gently on the center of the spreader to distribute the sample evenly on the aerobic plate. The spreader was removed from the surface of the plate and the plate was left undisturbed for at least one minute to allow the sample to form. Plates were incubated in stacks of no more than two plates (Incubator, Model #10-140, Quincy Lab Inc., IL) for 24 hours at 35 °C in a horizontal position with the clear side up. Petrifilms containing between 30 and 300 colony forming units (CFU) (or the highest number if below 30) were enumerated and converted into log CFU to accommodate the anticipated wide fluctuation common to biological data collection.

Initial microbial samples were also plated on Eosin Methylene Blue, MacConkey's agar and Salmonella shigella plates to determine the presence of generic *Salmonella* and *Escherichia coli*. Samples were plated by placing the agars on a flat surface and holding the pipette perpendicular to the agar, dispensing 1 mL of the obtained sample suspension onto the center of the agar. A glass "L" rod was used to spread the sample over the surface of the agar. The "L" rod was submerged in ethanol and flamed to prevent cross contamination between samples. The plates were allowed to aerobically dry and then placed in an incubator held at 35 °C for 24 to 48 hours. The Eosin Methylene Blue, MacConkey's agar and Salmonella shigella plates were then visually analyzed and colony forming units counted for the presence of *Salmonella* and *E. coli* by a trained lab technician.

**Sensory Panel.** In this study, trained panelists rated the effects of temperatures and aging times on the palatability attributes of the pork loin chops. Sensory panelists were trained

and selected according to the recommendations of the Research Guidelines for Cookery, Sensory Evaluation, and Instrumental Tenderness Measurements of Fresh Meat (AMSA 1995). The same six members of the trained sensory taste panel were utilized throughout the entire study to ensure that the data collected from the sensory panel was consistent.

Panelists were trained to identify quality characteristics of each sample. Prior to conducting sensory analyses, panelists were introduced to a variety of products that varied in tenderness and flavor ratings. Panelists rated each sample on a scale from one to eight, and each sensory characteristic was rated on a scale. The initial and sustained juiciness scale was: 1 = Extremely dry, 2 = Very dry, 3 = Moderately dry, 4 = Slightly dry, 5 = Slightly juicy, 6 = Moderately juicy, 7 = Very juicy, and 8 = Extremely juicy. The scale evaluating initial and overall tenderness was: 1 = Extremely tough, 2 = Very tough, 3 = Moderately tough, 4 = Slightly tough, 5 = Slightly tender, 6 = Moderately tender, 7 = Very tender, and 8 = Extremely tender. The amount of connective tissue was evaluated on the following scale: 1 = Abundant, 2 = Moderately abundant, 3 = Slightly abundant, 4 = Moderate, 5 = Slight, 6 = Traces, 7 = Practically none, and 8 = None. The scale for flavor intensity was: 1 = Extremely bland, 2 = Very bland, 3 = Moderately bland, 4 = Slightly bland, 5 = Slight intense, 6 = Moderately intense, 7 = Very intense, and 8 = Extremely intense. Finally, overall palatability was evaluated on the following scale: 1 = Extremely unsatisfied, 2 = Very unsatisfied, 3 = Moderately unsatisfied, 4 = Slightly unsatisfied, 5 = Slightly satisfied, 6 = Moderately satisfied, 7 = Very satisfied, and 8 = Extremely satisfied. Samples from both aging temperature groups (1.1 °C and 3.3 °C) were equally represented in the samples evaluated for sensory characteristics. Pork chops for sensory analysis were cooked using procedures described for Warner-Bratzler Shear Force. Each chop was trimmed of external fat and bone and fabricated consistent in size, 1.27cm X 1.27 cm and served at consistent internal temperatures of 71 °C. Six panel members for each session participated and samples were served two to five minutes following the cooking process. A total of 120 samples were evaluated by these six trained sensory panelists in this study. Samples were identified by loin, aging period, and temperature group. Each 2.54 cm X 2.54 cm sample was served with unsalted saltine crackers and distilled water to cleanse the palate of the panelists after each sample. Each panelist was instructed to chew each sample 10 times with their incisors and to dispose of the sample upon mastication.

**Statistical Analysis.** In order to obtain statistical results that were valid, repeatable, accurate, and true representatives of the population, statistical analysis was conducted using the Statistical Analysis System (Barr and Goodnight 1972). For sensory, shear force and microbial data procedure GLM in Statistical Analysis System was used. Model terms included storage temperature and aging length (in days). Least square means were estimated using the LSMEANS statement. When significant effects were detected ( $P < 0.05$ ), the PDIF option was used for mean separation.

## RESULTS AND DISCUSSION

Fresh meat is aged to enhance the overall palatability of the product. Aging meat increases tenderness over time, as well as the development of unique sensory characteristics (Dransfield 1994). Therefore, evaluating the effectiveness of temperature impacts on the wet aging of pork loin chops can ultimately lead to improvements in

sensory characteristics and more uniform products for facilitating the marketing of pork products.

**Cook loss.** In this study, cook loss was not significantly affected by ( $P > 0.05$ ) temperature treatment. Chops stored at 1.1 °C possessed a mean value of 16.69% cook loss and those chops stored at 3.3 °C had a mean value of 17.79% cook loss. The mean values for percent cook loss for the different aging periods were also shown to be insignificant ( $P > 0.05$ ). The most cook loss was observed for the chops aged for nine days (18.70% cook loss). The explanation of the variances in cook loss per day of age is not clearly obvious.

**Warner-Bratzler Shear Force.** Tenderness of pork has been found to be one of the most important quality factors for consumers. Results suggest that storage temperatures did not affect the Warner-Bratzler values ( $P > 0.05$ ).

However, Warner-Bratzler shear force values decreased as the days of the aging periods increased, (Figure 1,  $P < 0.05$ ). Day 0 was significantly less tender than day 3 of aging.

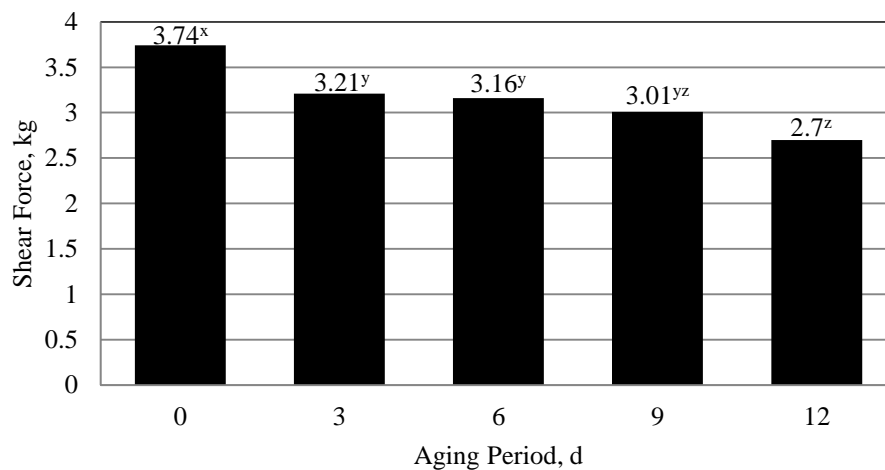


Figure 1. Effect of aging period on Warner-Bratzler shear force values of pork loin chops. <sup>x,y,z</sup> Within the figure, means with same superscript are not different ( $P < 0.05$ ).

Between days 3, 6, and 9 of aging, there were no differences between the Warner-Bratzler shear force values ( $P > 0.05$ ). A significant decrease between day six and 12 of aging ( $P < 0.05$ ) is represented in Figure 1, yet no differences were noted for day 9 versus day 12 of aging. Calkins and Seidman (1988) aged beef over a 14-day period and reported a 41.6% change in tenderness from days 3 to 6, 4.0% change in tenderness from days 6 to 12, and a 14.9% change from days 12 to 14. Data reported by Calkins and Seidman (1988) was similar to the results of this study. Data from Davis et al., (2004) indicated a reduction in Warner-Bratzler Shear Force values when the pork loins aged 1 day of age (2.61 kg), 7 days of age (2.26 kg), and 14 days of age (2.19 kg). The results from the Davis study support findings from this study. Results from this study indicate that as chops aged, the shear force mean values decreased.

**Microbial Evaluation.** Public awareness, concern, and economic impact have increased the number of studies conducted on food-borne pathogens. The increasing research from pork loin chops has led to the developments of more sensitive methods of pathogen prevention, detection, and identification. In this study, initial samples were obtained to determine the presence of generic *Salmonella* and *E. coli*. Samples collected tested negative for both types of bacteria. As represented in Figure 2, total plate counts indicated increasing amounts of bacteria over the various aging periods and higher levels of bacteria in the group stored at 3.3 °C versus 1.1 °C at day 12 only. Findings were supported by Borch et al. (1996), who reported that decreasing refrigeration temperatures subsequently decreased bacterial growth and also affected the shape of the bacteria. Thus, the highest bacteria level was reported at the highest storage temperature and oldest day of aging. Indicated in Figure 2, days 0, 3, and 6 of aging possessed significantly ( $P < 0.05$ ) lower levels of bacteria as compared to days 9 and 12 of aging. Day 12 possessed significantly higher levels of bacteria compared to days 0, 3, 6, and 9 ( $P < 0.05$ ), yet only at the higher storage temperature.

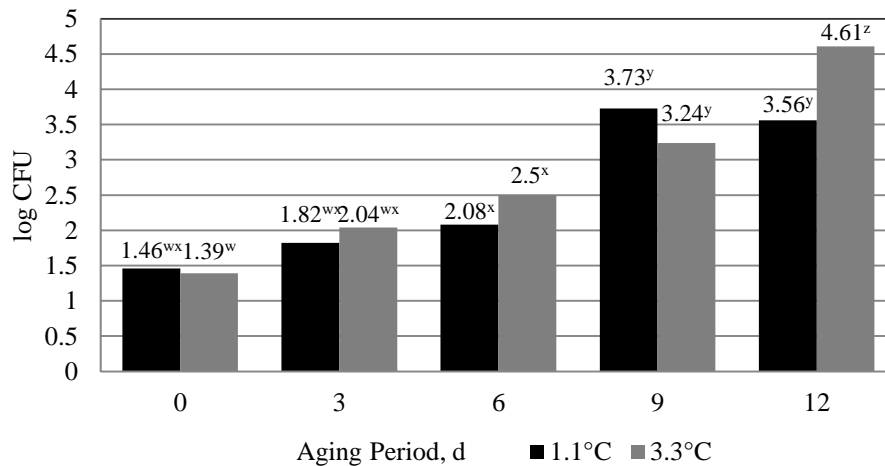


Figure 2. Effects of aging period and total plate counts on shelf-life of pork loin chops. <sup>w, x, y, z</sup> Means with uncommon superscript differ ( $P < 0.05$ ).

However, bacteria levels reported by Boers et al. (1994) concluded that if stored properly the pork products do not spoil at a microbial level until 35 days of age. Results from this study indicate that as the loin chops aged, the bacteria levels increased and the aging temperature had no significant affect on bacteria levels except at day 12 of aging.

**Sensory Evaluation.** Sensory evaluation continues to demonstrate the value and uniqueness of the information it obtains and clearly differentiates it from other product sources (Sidel and Stone 1993). Samples from both of the aging temperature groups were represented in the samples evaluated by the trained sensory panelists. In this study, initial juiciness, sustained juiciness, initial tenderness, overall tenderness, amount of connective tissue, flavor intensity, and overall palatability were evaluated on an eight point scale. Statistics revealed that temperature storage did not significantly ( $P > 0.05$ ) affect any of these palatability characteristics.

**Initial Juiciness and Sustained Juiciness.** Juiciness of a product is determined by the amounts of water and lipids remaining in muscle after product have been cooked. As stated previously, results from this study suggested that temperature treatment did not affect initial juiciness ( $P > 0.05$ ). However, aging periods significantly affected the initial juiciness and sustained juiciness, respectively, as shown in Figure 3. In Figure 3, day 0 was significantly less juicy than days 3, 9, and 12 of aging. Days 0 and 6 exhibited no difference in initial juiciness ( $P > 0.05$ ).

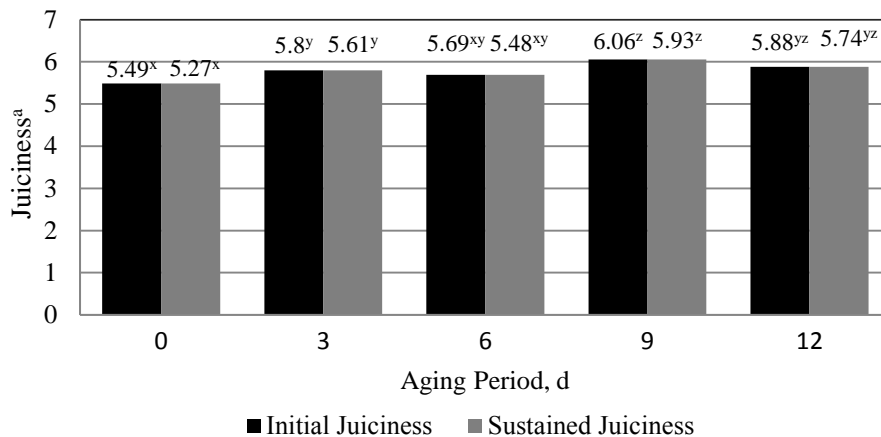


Figure 3. Effect of aging period on initial and sustained juiciness of pork loin chops.

<sup>x,y,z</sup> Within the figure, means with same superscript are not significantly different ( $P < 0.05$ ).

<sup>a</sup> Defines the scale used to evaluate the sample: (1 = Extremely dry, 2 = Very dry, 3 = Moderately dry, 4 = Slightly dry, 5 = Slightly juicy, 6 = Moderately juicy, 7 = Very juicy, and 8 = Extremely juicy).

Day 9 was significantly juicier than days 0, 3, and 6 of aging. Sustained juiciness represented indicated that day 0 was significantly less juicy than days 3, 9, and 12. Similar to initial juiciness, day 0 and 6 showed no difference in sustained juiciness values ( $P > 0.05$ ). Over the various aging periods, day 9 was significantly juicier than days 0, 3, and 6 days of aging. Initial juiciness and sustained juiciness possessed similar trends in levels of juiciness over the aging periods. As the chops aged the levels of initial and sustained juiciness significantly increased ( $P < 0.05$ ). According to Hansen et al. (2004), for pork loin chops aged 0, 4, and 7 days postmortem, there was an overall increase in juiciness occurring as the days of age increased.

**Initial Tenderness and Overall Tenderness.** Sensory characteristics of initial tenderness and overall tenderness were not significantly affected by temperature ( $P > 0.05$ ) as indicated in Figure 4.



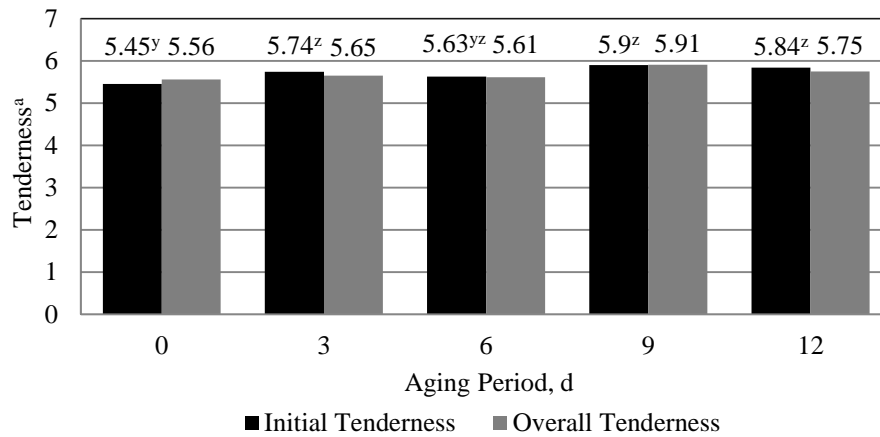


Figure 4. Effect of aging period on initial and overall tenderness of pork loin chops.  
<sup>y,z</sup> Within the figure, means with same superscript are not significantly different ( $P < 0.05$ ).  
 Columns lacking a common superscript significantly differ ( $P < 0.05$ ).

<sup>a</sup> Defines the scale used to evaluate the sample: (1 = Extremely tough, 2 = Very tough, 3 = Moderately tough, 4 = Slightly tough, 5 = Slightly tender, 6 = Moderately tender, 7 = Very tender, and 8 = Extremely tender)

These findings agree with those of Pierson and Fox (1976), who concluded that ultimate tenderness was not related to the aging temperature of beef longissimus muscle. In Figure 4, day 0 was less tender than days 3, 9, and 12 ( $P < 0.05$ ). There are no differences between days 3, 6, 9, and 12 in initial tenderness values. According to the trained sensory panelists overall tenderness values were not different across all treatment groups ( $P > 0.05$ ). In contrast, Pierson and Fox (1976) reported that tenderness increased as length of aging increased in beef longissimus muscle.

Temperature showed no effects on the amount of connective tissues as noted by the trained sensory panelists. Also, aging effects did not show differences for connective tissue values ( $P > 0.05$ ) based on the sensory panelists. According to Jeremiah and Gibson (2003), as beef is held postmortem the amount of perceptible connective tissue decreased as postmortem aging was prolonged. Contrary to Jeremiah and Gibson (2003), Pierson and Fox (1976) stated that the length of aging time and temperature had no effect on the amount of connective tissue in a sample.

**Flavor Intensity.** Flavor intensity was not affected by temperature. In Figure 5, day 0 of aging the flavor intensity possessed lower flavor intensity as compared to days 3, 9, and 12 ( $P < 0.05$ ).

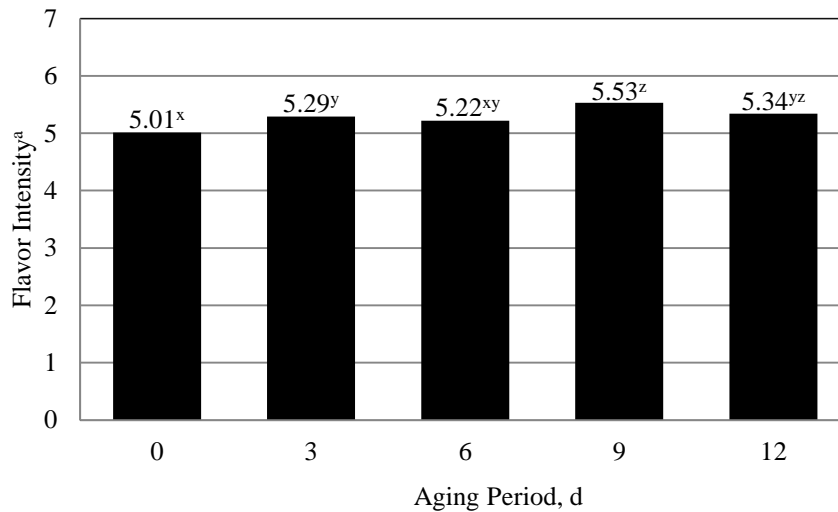


Figure 5. Effect of aging period on flavor intensity of pork loin chops.

<sup>x,y,z</sup> Within the figure, means with same superscript are not significantly different ( $P < 0.05$ ).

<sup>a</sup> Defines the scale used to evaluate the sample: (1 = Extremely bland, 2 = Very bland, 3 = Moderately bland, 4 = Slightly bland, 5 = Slight intense, 6 = Moderately intense, 7 = Very intense, and 8 = Extremely intense).

In consideration of days 3, 6, and 12, there were no significant changes in flavor intensity ( $P > 0.05$ ). Day 9 possessed the most intense flavor ( $P < 0.05$ ), yet showed no difference when compared to day 12. Flavor intensity was affected by aging but there was not a clear explanation or pattern explaining the significant changes in flavor intensity. According to data from Hendrix et al. (1963), 1,541 members of a consumer panel criticized pork for having an unsatisfactory flavor. Chops with higher percentages of expressible juices and lipids provided the most intense flavor (Davis et al. 1975). These findings disagree with the slightly intense flavor profile that the trained sensory panelists noted in this study.

Temperature did not significantly affect overall palatability. Furthermore, days of aging did not significantly affect overall palatability of the loin chops as detected by the sensory panel. Jennings et al. (1978) found similar results indicating that there was no substantial improvement in overall palatability in beef to warrant vacuum packaged storage for those cuts that are more than 10 days postmortem. In contrast of Jennings et al. (1978), Jeremiah and Gibson (2003) indicated beef wet-aged past 28 days possessed unique palatability characteristics.

## CONCLUSION

Product tenderness continues to be of concern in the meat industry. Results from this study may assist retail and foodservice operators in establishing appropriate postmortem aging times for bone-in pork loin chops. Clearly, pork tenderness is a complex sensory attribute influenced by many factors. The basis of pork tenderness and tenderization must be understood before this quality characteristic can be improved. In

this study, the effectiveness of temperature controlled pork wet aging and its relationship to tenderness, juiciness, and shelf life of pork loins was evaluated.

Results from this study indicated that neither temperature nor aging period had any effect on the cook loss of loin chops. Furthermore, temperature did not affect the Warner-Bratzler shear force values; however, varying aging periods had significant effects on the Warner-Bratzler values. As the loin chops aged, the Warner-Bratzler values significantly decreased therefore, increasing the level of tenderness in the product. By increasing the length of times that pork loin chops are wet-aged, the more tender the product will become.

In addition, this study proved that as the length of time the loin chops were aged the microbial levels significantly increased (APC), yet not to dangerous levels that would support food-borne illnesses. The two temperature storage levels did not have an effect on the microbial levels. Sensory results showed that initial juiciness, initial tenderness, and flavor increased with aging of pork loin chops, yet no differences were reported for overall tenderness and palatability. Understanding the process of aging can result in providing the pork industry with new methods of creating a more uniform more tender product while maintaining proper levels of food safety and meeting all sensory levels required by the consumer.

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