Title: Projecting changes in pig growth, pork quality, eating experience, and muscle physiology due to increasing live and carcass weights, **NPB #17-090**

Investigator: Dustin Boler

Institution: University of Illinois

Date Submitted: 1 January, 2019

revised

Industry Summary:

Marketing weight is an important economic variable that impacts the productivity and profitability of finishing pig production. Marketing weight has been increasing over the past decades driven by the dilution of fixed production cost over more weight per pig and the improvement of genetic selection of lean-type pigs. Along with it, pork carcass weights have increased by an average of 1.4 lb per year. While heavier market weights are associated with poorer feed efficiency, little data exists to understand how it influences other important production and economic factors. Little to no data are available to predict how heavier pigs (e.g. 320 lb. and above) are influenced by farm facilities (e.g. floor space per pig) or how meat quality or consumer acceptance is related to carcass size when pigs are harvested at body weights approaching 400 lb. Therefore, the primary objective of this study was to determine the space allowance needed to evaluate the carcass quality of pigs with increased live weights that might be expected in the next 50 years. To achieve this primary objective we had five specific goals: 1) compare k-value space allowances, 2) compare temperature decline of hams and loins, 3) compare fresh loin quality (muscle pH, color, marbling, firmness, and predicted tenderness) of loins, 4) determine how increased carcass size affects eating experience and purchasing preferences of consumers, and 5) compare muscle physiology, hypertrophy, and fiber types.

A total of 976 pigs were raised in a 160-d growth study. Pigs were fed 1 of 6 dietary treatments with 8 pens per treatment. The first four treatments reduced space allowance per pig via initial pen stocking density and had only one final marketing event. The fifth and sixth treatments consisted of different pig removal strategies. Pens of pigs were weighed and feed disappearance was measured on d 0, 13, 27, 41, 55, 69, 82, 93, 108, 122, 135, 147, and 160 to determine ADG, ADFI, and feed efficiency (F/G). When pigs were removed due to illness or death, pen gates were adjusted. Pigs were given ad libitum access to feed and water throughout the study. Diets were corn- and soybean meal-based and included 30 to 40% corn dried distillers grains with solubles until the final dietary phase. Diets were fed in 6 sequential phases from approximately 48 to 70, 70 to 120, 120 to 180, 180 to 230, 230 to 270, and 270 lb until the end of the study. The diets were formulated to meet or exceed NRC (2012) requirement estimates for finishing pigs and contained 1.18, 1.03, 0.88, 0.78, 0.76, and 0.77% standardized ileal digestible (SID) Lysine (Lys) in phases 1 through 6.

All pigs were raised and slaughtered in the Midwest US. Identity of the carcasses were maintained throughout the slaughter process to allow for carcass weight relationships with meat quality, consumer ratings, and fiber type characteristics to be determined. In total, 666 carcasses were evaluated.

The following data were collected from approximately all carcasses:

- Hot carcass weight
- Carcass composition- back fat and loin depth (via Fat-O-Meater)
- Boneless loin weight
- Subjective color, marbling, and firmness of boneless loins
- Instrumental color of the boneless loins
- Ultimate pH of the boneless loins

The following data were collected on approximately 33 % of all carcasses:

- Ham primal weight
- Instrumental color of the gluteus medius
- Ultimate pH of the gluteus medius
- Iodine Value
- Longissimus dorsi and semimembranosus muscle temperature decline
- Loin muscle slice shear force determination at 160 and 145 ^{o}C
- Purge and cook loss
- Aged chop quality measurements
  - Subjective color, marbling, and firmness
  - Instrumental color
  - pH
- Proximate analysis
- Trained sensory panels for tenderness, juiciness, and flavor
- Consumer palatability ratings
- Consumer visual ratings

The following data were collected on approximately 50 carcasses:

- Fiber type determination
- Fiber type area percentage

Findings from the live phase are consistent with others that evaluate more traditional market weights where growth performance is reduced prior to pigs reaching their k-value, and align with recent models that predict the rate of change in growth performance as pigs are allowed more spacing during the finishing period. Similarly, it appears that pigs respond to removal of the heaviest pigs in the pen before market with the remaining pigs in the pen demonstrating compensatory gain after being provided with increased space. Additionally, results indicate that decreasing space allowance for heavy weight pigs reduced growth, intake, and final BW, although use of pig removals prior to final marketing may allow producers to maximize number of pigs marketed while balancing reduced growth performance generally accompanied with increased stocking density. Furthermore, growth continued to increase until approximately 340 lb, indicating a potential opportunity for swine producers to capture lean growth at much heavier weights than previously predicted.

Temperature decline of hams and loins were slower in heavier carcasses. It is not surprising that heavier carcasses produced heavier hams, and loins, as well as, more back fat and loin depth. Additionally, as carcass weight increased there was an increase in trained tenderness scores and decrease in slice shear force, indicating that as pigs get heavier, they become more tender. Water holding capacity also improved as carcasses got heavier, reducing purge and cook loss from chops.

Consumers rated chops from heavier carcasses as more tender. Additionally, they rated more chops from the heavy weight category as acceptable in terms of juiciness. The lowest percentage of chops rated as unsatisfactory were from the heavy weight group. However, weight group had no effect on acceptable flavor or overall like. Top loin chops from heavier carcasses also had improved tenderness compared to chops from lighter carcasses, similar to the results observed from the trained taste panel.

Weight of carcasses had no effect on fiber type or fiber type area percentage within the loin muscle.

From these results, the following conclusions can be made:

1) Decreasing space allowance for heavy weight pigs reduced growth, intake, and final BW, although use of pig removals prior to final marketing may allow producers to maximize number of pigs marketed while balancing reduced growth performance generally accompanied with increased stocking density. A pig removal strategy via multiple marketing events may provide producers a means to maximize stocking density while mediating reduced performance. There is a potential opportunity for swine producers to capture lean growth at much heavier weights.
2) Temperature decline of hams and loins is slowed as carcasses reach heavier weights.
3) As expected, increasing carcass weight will lead to heavier primal weights. Heavier pigs increase tenderness and water holding capacity of pork chops.
4) As hot carcass weights increase, there are no negative effects on loin quality or palatability characteristics. Tenderness was positively affected by increased weight; increasing the likelihood a consumer will have a satisfactory eating experience and thus encouraging repeat purchases.
5) Increases in carcass weight had no effect on muscle type percentage or area.

Keywords: body weight, hot carcass weight, growth, pork quality, tenderness

Scientific Abstract:

The primary objective of this study was to determine the space allowance needed to evaluate the carcass quality of pigs with increased live weights that might be expected in the next 50 years. To achieve this primary objective we had five specific goals: 1) compare k-value space allowances, 2) compare temperature decline of hams and loins, 3) compare fresh loin quality (muscle pH, color, marbling, firmness, and predicted tenderness) of loins, 4) determine how increased carcass size affects eating experience and purchasing preferences of consumers, and 5) compare muscle physiology, hypertrophy, and fiber types. A total of 976 pigs (PIC 327 × L42, initially 48.6 ± 3.4 lb body weight [BW]) were used in a 160-d growth study. Pens were blocked by location within the barn and allotted to 1 of 6 treatments with 8 pens per treatment. The first four treatments reduced space allowance per pig via initial pen stocking density and had only one final marketing event. The fifth and sixth treatments consisted of different pig removal strategies. Average daily gain (ADG), average daily feed intake (ADFI), and final BW decreased (linear, $P < 0.001$) during the overall experimental period (d 0 to 160) as space allowance decreased. When comparing treatments with multiple marketing events to those with similar initial stocking density (23 pigs per pen), there was no evidence for differences ($P > 0.05$) for overall ADG or ADFI; however, overall feed efficiency was improved ($P < 0.05$) for pigs initially stocked at 7.1 ft^2/pig and marketed four times compared to both treatments that initially allowed 7.7. ft^2/pig, regardless of marketing structure. Additionally, overall F/G was improved for pigs that began at 7.7 ft^2/pig and had 3 marketing events compared to the treatment that also began at 7.7 ft^2/pig but had only a single marketing event. Once the marketing events began on d 93, ADG and F/G were improved ($P < 0.05$)

for the remaining pigs in the pen for the rest of the trial (d 93 to 160) for both multiple marketing treatments, compared to the 7.7 ft^2/pig allowance where all pigs were marketed together at the end of the trial. Pigs were slaughtered in a federally inspected facility under the supervision of the USDA Food Safety and Inspection Service. Pigs were slaughtered on 2 separate days using CO2 immobilization and terminated via exsanguination. Data were collected on a total of 666 carcasses at the production facility. Early quality measurements were collected on the ham (n =203) and loin (n = 613). Aged quality measurements were collected on chops at 14 d. Coefficients of determination (R^2) were calculated to determine the predictability of HCW on quality characteristics, sensory traits, and fiber type characteristics. Hot carcass weight explained the greatest proportion of variability in ham weight ($R^2 = 0.7261$, $P < 0.0001$). As HCW increased, back fat ($R^2 = 0.2097$, $P < 0.0001$), loin depth ($R^2 = 0.1278$, $P < 0.0001$), loin weight ($R^2 = 0.1803$, $P < 0.0001$), and chop weight ($R^2 = 0.2170$, $P < 0.0001$) also increased. There was a decrease in calculated iodine value ($R^2 = 0.0144$, $P = 0.0035$) and estimated lean ($R^2 = 0.2352$, $P < 0.0001$). Additionally, at 14 d there was a decrease in pH value ($R^2 = 0.0201$, $P = 0.0187$). As carcasses got heavier, there was an increase in tenderness due to a decrease in slice shear force for both 160 ºF ($R^2 = 0.0810$, $P < 0.0001$) and 145 ºF ($R^2 = 0.0241$, $P = 0.01$) and an increase in trained tenderness scores ($R^2 = 0.0352$, $P = 0.0017$). Furthermore, there was a decrease in cook loss for both 160 ºF ($R^2 = 0.0464$, $P < 0.0003$) and 145 ºF ($R^2 = 0.0222$, $P = 0.0190$) as carcass weight increased. For loins targeted for consumer palatability ratings, pork loins (n = 200) were collected from 4 different hot carcass weight groups: light weight group (less than 246.5 lb; LT), medium-light weight group (246.5 to 262.5 lb; MLT), medium-heavy weight group (262.5 to 276.5 lb; MHVY), and a heavy weight group (276.5 lb and greater; HVY). Instrumental color, visual color and marbling, and pH were collected for each loin prior to fabrication. Loins from all weight groups differed ($P < 0.05$) in weight (LT < MLT < MHVY < HVY). No carcass weight effects ($P > 0.05$) were found for loin instrumental color, visual color, visual marbling, purge loss, and pH. Carcass weight did not affect ($P > 0.05$) juiciness, flavor, or overall like ratings, but did affect ($P < 0.05$) tenderness ratings. Chops from the HVY group were rated as more ($P < 0.05$) tender compared to chops from the LT weight group. Weight group did not contribute ($P > 0.05$) to the percentage of chops rated acceptable for flavor and overall like. The greatest ($P < 0.05$) percentage of samples were rated acceptable for juiciness for chops from the HVY weight group, and the lowest ($P < 0.05$) percentage of acceptable ratings for tenderness for chops were from the LT weight group. Consumers perceived the lowest ($P < 0.05$) percentage of chops from the HVY group as unsatisfactory quality in comparison to chops from the 2 lightest weight groups. These results indicate top loin chops from heavier weight carcasses have improved tenderness compared to chops from lighter carcasses.

Contact: Dustin Boler
University of Illinois
dboler2@illinois.edu
(217) 300-4847

Introduction:

Space requirements for growing pigs are typically established by using the k-value determined by Gonyou et al. (2006). They estimated that every decrease in k less than 0.0336 resulted in decreased average daily gain (ADG) and average daily feed intake (ADFI) for grow-finish pigs reared on fully-slatted flooring. While Flohr et al. (2016) concluded the k-value established by Gonyou et al. (2006) was a valid predictor of the effect of space allowance on growth performance for pigs raised to 308 lb, others demonstrated the k-value may underestimate the space allowance needed before growth performance is reduced. In addition to adjusting the initial stocking density of a pen, topping is another strategy that producers implement to provide finishing pigs increased floor space. This method involves the removal of one or more of the heaviest pigs in the pen, prior to the final marketing event. This additional space allows the remaining pigs to reach the target market weight and provides more consistent weights at the packing plant, resulting in fewer packer discounts for variability. Wu et al. (2017) reviewed the current understanding of raising pigs to heavier market weights and identified animal housing and identifying optimal floor space requirements as critical needs for future research.

Between 1995 and 2017, average hot carcass weight of U.S. pork carcasses increased from 180 lb to 211 lb (USDA, 2018), which is an increase of approximately 17%. At current rates, pork carcasses in the U.S. will weigh on average, 231 by the year 2030 and over 260 lb by 2050. Although this represents an increase in throughput efficiency due to increases in economy of scale, projecting continued increases in the future raises some concerns. The ending live weight of the average broiler in the U.S. has increased from 4.5 lb in 1995 to 6.3 lb in 2017 (USDA, 2018). This is a 34% increase in body weight. This increase in broiler weight is often quoted as the source of increased adverse muscle conditions such as woody breast syndrome, muscle striping, and pale, soft, and exudative (PSE) meat (Kuttappan et al., 2016). These conditions result in a poor eating experience and reduced consumer confidence of poultry. Consumers are more influenced by color than any other quality factor when purchasing meat (Mancini and Hunt, 2005). Previously, slower chilled loins were paler in color, had less perceived marbling, and were more tender compared with loins that chilled more rapidly (Shackelford et al., 2012). Additionally, Arkfeld et al. (2016) reported that ham temperature decline lags behind loin temperature decline continuously throughout the chilling process and even at the time of fabrication at 22 h postmortem. Furthermore, loins and hams from carcasses weighing 231 lb chilled slower than loins and hams from carcasses weighing 187 lb (Overholt et al., 2018). Therefore, the ability to appropriately chill carcasses may become compromised as carcass weight increases, ultimately compromising the chilling rates in pork carcasses, providing the potential to reduce their quality.

In order for consumers to have a satisfactory eating experience, their expectations for tenderness, juiciness, and flavor must be met. Tenderness is the most crucial factor in pork palatability. It is unclear what the impact of increased carcass weight has on these traits because the few published studies that have attempted to measure this produced conflicting results. Still, many of these studies have used weight ranges that were less than current industry trends and, in many cases, used genetics that are not common to U.S. production systems. When a consumer's expectations are met for palatability, it encourages repeat purchases. Therefore, as United States pork hot carcass weights increase, it is possible that consumers may find the palatability traits of tenderness, juiciness, and flavor of heavier weight carcasses unacceptable. Little research exists that has evaluated the impact of elevated hot carcass weights on eating quality.

Objectives:

The PRIMARY objective of this research was to determine the space allowance needed and evaluate the carcass quality of pigs with increased live weights that might be expected in the next 50 years. To accomplish our overall goal, we proposed five specific objectives:

Objective 1: Compare k-value space allowances of market weight pigs representative of current industry weights with those that are representative of projected carcass weights for the near and distant future.

Objective 2: Compare temperature decline of loins and hams from pigs that are representative of current industry carcass weights with carcasses that are representative of projected carcass weights for the near and distant future.

Objective 3: Compare fresh loin quality (muscle pH, color, marbling, firmness, and predicted tenderness) of loins from pigs representative of current industry carcass weights with carcasses that are representative of projected carcass weights for the near and distant future.

Objective 4: Determine how increased carcass size affects eating experience and purchasing preferences of consumers.

Objective 5: Compare muscle physiology, hypertrophy, and fiber types of pigs that are representative of current industry carcass weights with carcasses that are representative of projected carcass weights for the near and distant future.

Materials & Methods:

The Kansas State Institutional Animal Care and Use Committee approved the protocol used for the live phase of this experiment. Pigs were slaughtered in a federally inspected facility under the supervision of the USDA Food Safety and Inspection Service. Meat purchased from that facility was transported to the USDA Meat Animal Research Center (Clay Center, NE) and then to the University of Illinois Meat Science Laboratory (Urbana, IL) or to the Kansas State University Meat Science Laboratory (Manhattan, KS).

Pigs and Experimental Design

The trial was conducted at a commercial research facility owned and operated by Holden Farms, Inc. (Northfield, MN). The barn was double-curtain sided with completely slatted concrete flooring and deep pits for manure storage. Each pen (10 × 18 ft) was equipped with adjustable gates and contained a 3-hole, dry feeder (Thorp Equipment, Inc., Thorp, WI) and a double-sided pan waterer. Feed additions were delivered and recorded using a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN).

A total of 976 pigs (PIC 327 × L42, initially 48.6 ± 3.4 lb BW) were used. Pen served as the experimental unit, and there were 8 replicate pens per treatment. Pens were blocked by location within the barn and allotted to 1 of 6 dietary treatments. The first four treatments (Table 1) consisted of increased initial stocking density and did not utilize topping strategies: 1) 14 pigs/pen (12.7 ft^2/pig); 2) 17 pigs/pen (10.4 ft^2/pig); 3) 20 pigs/pen (8.9 ft^2/pig); and 4) 23 pigs/pen (7.7 ft^2/pig). The fifth treatment began with 25 pigs/pen (7.1 ft^2/pig) with 3 pigs/pen topped on d 93, then on d 122 pens were topped to a common inventory of 20 pigs/pen, and a final topping event occurred on d 147 to achieve a common pen inventory of 17 pigs/pen. The sixth treatment started with 23 pigs/pen (7.7 ft^2/pig) and was topped to a common inventory of 20 pigs/pen on d 108 with a final topping event occurring on d 147 to reach a common inventory of 17 pigs/pen.

Pens of pigs were weighed and feed disappearance was measured on d 0, 13, 27, 41, 55, 69, 82, 93, 108, 122, 135, 147, and 160 to determine ADG, ADFI, and feed efficiency (F/G). An additional response criteria of adjusted F/G was calculated to adjust F/G to a common BW of 285 lb by using an adjustment of 0.0048 for every 1 lb difference in body weight. In the case of a pig removal due to illness or death, pen gates were adjusted to maintain the desired floor space allowance.

Pigs were given *ad libitum* access to feed and water throughout the study. Diets were corn- and soybean meal-based and included 30 to 40% corn dried distillers grains with solubles until the final dietary phase (Table 2). Diets were fed in 6 sequential phases from approximately 48 to 70, 70 to 120, 120 to 180, 180 to 230, 230 to 270, and 270 lb until the end of the study. Diets were formulated to meet or exceed NRC (2012)[1] requirement estimates for finishing pigs and contained 1.18, 1.03, 0.88, 0.78, 0.76, and 0.77% standardized ileal digestible (SID) Lysine (Lys) in phases 1 through 6, respectively. All diets were fed in meal form and manufactured at a commercial feed mill (Blooming Prairie, MN).

Abattoir Data Collection

Upon completion of the live phase portion of the experiment, pigs were given lot tattoos based on pen, loaded on trucks and transported approximately 351 miles (565 km) to a USDA federally inspected abattoir. Pigs were provided ad libitum access to water but no access to feed during lariage. Time in lairage followed normal operating procedures of the abattoir. Pigs were slaughtered on 2 separate days

using CO_2 immobilization and terminated via exsanguination. Immediately after evisceration, a sequential identification number was written on the shoulder of each carcasses and the respective lot tattoo recorded. Carcasses were measured for HCW, back fat depth, and loin depth. Back fat depth and loin depth were evaluated using the Fat-O-Meater probe (FOM; SFK Technology A/S, Herlev, Denmark) perpendicular to the muscle between the third and fourth from the last ribs. The FOM is an optical probe that measures the difference in light reflectance as it passes through fat and muscle tissue. At approximately 39 minutes postmortem, temperature data loggers (Thermochron-iButton-40C-thru-85C, Embedded Data Systems, Lawrenceburg, KY) were inserted into the loin, ham, and internal cavity of approximately every third carcass. The longissimus dorsi temperature logger was placed at approximately the tenth rib, semimembranosus temperature logger was placed posterior to the symphysis pubis bone, and the ambient temperature recorder was placed by attaching the logger to a shroud pin in the spinous process of the thoracic vertebrae at approximately the fifth rib. Data loggers recorded time and temperature at 1 min intervals. Temperature decline was recorded before entering the blast-chiller for approximately 95 minutes and then held in equilibration bays. Data loggers were removed from the carcasses at approximately 17 h postmortem as they entered the cutting floor.
After exiting the blast, carcasses were held in temperature equilibration bays until fabrication. During temperature equilibration a target of one third of the carcasses were identified for loin and ham quality evaluation. The vertebral column and the medial side of the ham were labeled with a corresponding sequence numbers that matched the shoulder sequence for identification during fabrication. At approximately 17 h postmortem, carcasses were fabricated into primal pieces; whole legs (NAMP# 401; NAMI, 2014) and pork loin, bone in (NAMP# 410; NAMI, 2014). Legs with sequence numbers were collected and placed into combos to be weighed and evaluated for meat quality traits. Leg primal weight was recorded, and instrumental color (L*, a*, and b*) was measured with a Konica Minolta CR-400 colorimeter (Minolta Camera Company, Osaka, Japan) using D65 illuminant, 2° observer angle, and an 8-mm aperture on the gluteus medius of the ham face on 203 hams in the population. Additionally, pH was measured on the gluteus medius of the ham face with a REED SD-230 pH meter (Reed Instruments, Wilmington, NC) fitted with a PHE-2385 glass combo electrode (Omega Engineering, Inc., Stamford, CT) on the gluteus medius of the ham face. During loin fabrication, loins were cut into boneless Canadian back loins (NAMP# 414; NAMI, 2014). An identifier button was placed in the boneless center-cut of each loin. Additionally, on the ventral side of the boneless loin, fresh muscle color (6-point visual scale; NPPC, 1999), marbling (10-point visual scale; NPPC, 1999), and firmness (5- point subjective scale; NPPC, 1991) were evaluated on the loin boning and trimming line at the time of cutting by an industry professional with over 10 yr of pork quality research experience. Color, marbling, and firmness scores were evaluated at a consistent location to allow for a consistent oxygenation of the loin muscle. Instrumental color (L*, a*, and b*) of the longissimus muscle (LM) was measured on the ventral side at approximately 25 and 75% the length of the loin using a Hunter Miniscan XE Plus colorimeter (Hunter Associates Laboratory, Inc., Reston, VA) with illuminant D65, 10° observer angle, and 25-mm port. Ultimate (>22 h postmortem) pH was measured on the ventral side at approximately the 10^{th} rib with a HI 98160 Microprocessor Logging pH/ORP Meter (Hanna Instruments) fitted with a PHE-2385 glass combo electrode. After early postmortem evaluations, a 0.8-in-thick cross-section sample from 60 loins, slaughtered on day one, was cut from the posterior end of the longissimus, packaged in whirl pack bags, and transported in coolers to the University of Illinois for fiber type determination. Additionally, carcasses were grouped by hot carcass weight into a light group (less than 246 lb; LT), medium-light group (246 to 262 lb; MLT), medium-heavy group (262 to 276 lb MHVY), and heavy group (276 lb and greater; HVY). Whole boneless pork loins (n = 200, Institutional Meat Purchase Specification #414; North American Meat Processors Association, 2014) from the 4 separate weight treatments were collected (n = 100/d; n = 25/treatment/d) and transported back to Kansas State University Meat Laboratory (Manhattan, KS).

Iodine Values

As carcasses exited the chiller, approximately 3.81-cm-diameter adipose tissue cores (consisting of all 3 adipose layers) were collected from the clear plate (adipose tissue located over the scapula and thoracic vertebra) near the dorsal midline of the left side of every carcass. Iodine values (IV) were measured using the Bruker, near-infrared technology (Bruker, 2016).

Loins

Figure 1. Illustration of the standardized loin used to assign chops to various meat quality assessments. Color coding indicated which parameter each chop was assigned.

Whole boneless pork loins (Institutional Meat Purchase Specification #414; North American Meat Processors Association, 2014) from the 4 separate weight treatments described above were collected and transported to the USDA Meat Animal Research Center (MARC). A total of 280 loins from the entire population was vacuum-packaged, boxed, and transported. Upon arrival at MARC loins were immediately placed on carts in a single-layer and ventral side up. Loins were weighed (loin weights accounted for the weight of the packaging material) to record initial loin weight and were stored at 4 °C until 14d postmortem. At 14 d postmortem, loins were removed from the packaging and weighed to determine aged weight. Purge loss was calculated: [(Initial weight, g – aged weight, g) / initial weight, g] × 100. At 14 d postmortem, loins were prepared for slicing with a Grasselli NSL 400 portion meat slicer (Grasselli SPA, Albinea, Italy) similar to Harsh et al. (2017). The posterior end of each loin (approximately 4 cm-long) was removed by a straight cut perpendicular to the length of the loin at a point 5-cm posterior to the anterior tip of gluteus accessories. The anterior end of the loin was removed by a second cut made 396-mm anterior to the first cut leaving a 396-mm-long center-cut loin section that fits the width of the Grasselli NSL 400 portion meat slicer. This approach maximized yield of chops with the greatest proportion of their mass/cross-sectional area comprised of longissimus and excluded chops with a high proportion of their mass/cross-sectional area comprised of other muscles (spinalis dorsi, multifidus dorsi, gluteus medius, and gluteus accessorius). Additionally, this approach standardized anatomical location of chop assignment across loins. Chops were numbered starting from the anterior end with chop 1, proceeding to the posterior end with chop 13 (Fig 1).

Slice Shear Force

Chops 3, 4, 5 and 6, were used for determination of slice shear force (SSF). Immediately after cutting, fresh (never frozen) chops were weighed to record initial weight. The following day (15 d postmortem), chops were cooked using a belt grill (Magigrill, model TBG60; MagiKitch'n Inc., Quakertown, PA) to a desired internal temperature of 145°F for chops 3 and 5 and 160°F for chops 4 and 6. Cooked chops were weighed and cooking loss was calculated: [(Initial weight, g – cooked weight, g) / initial weight, g] × 100. Slice shear force was measured using the procedures of Shackelford et al. (2004) on 2 chops for each desired internal temperature. Immediately after cooking, a 0.5-in-thick, 2-in-long slice was removed from each steak parallel to the muscle fibers. Each sample was sheared once with a flat, blunt-end blade using an electronic machine (model 4411; Instron Corp.). The SSF values from the 2 chops assigned to each temperature end point were then averaged, giving one SSF for chops cooked to 145°F and one SSF for chops cooked to 160°F used for all analyses.

Aged Quality

From each loin, chops 2 (anterior) and 11 (posterior) were used to measure muscle color (6-point visual scale; NPPC, 1999), marbling (10-point visual scale; NPPC, 1999), and firmness (5- point subjective scale; NPPC, 1991) after allowing at least 20 min of oxygenation. Instrumental color (L*, a*, and b*) was measured on both chops using a Hunter Miniscan XE Plus colorimeter (Hunter Associates Laboratory, Inc., Reston, VA) with illuminant D65, 10° observer angle, and 25-mm port. Ultimate pH was measured on both chop faces with a HI 98160 Microprocessor Logging pH/ORP Meter (Hanna Instruments). Measurements from both chops were averaged and that value was used for all analyses. Following this, chops 2, 8, and 11 were vacuum packaged, frozen and transported to the University of Illinois Meat Science Laboratory for intramuscular extractable lipid determination and trained sensory evaluation.

Proximate Composition

Chops used for analysis of moisture and extractable lipid were allowed to partially thaw at 72°F, taking care to prevent exudation, and trimmed of all subcutaneous fat and secondary muscles before homogenization in a Cuisinart (East Windsor, NJ) food processor. The homogenate was used to determine moisture content. Briefly, 10-g samples were weighed in duplicate and placed in a drying oven at 230°F for at least 24 h. After drying, samples were weighed to quantify moisture loss and lipid was extracted using an azeotrophic mixture of chloroform and methanol (87:13) as described by Novakofski et al. (1989). Samples were returned to the drying oven for at least an additional 24 h before collecting a lipid extracted weight. Moisture and extractable lipid percentages were determined by the difference between initial weight, dried weight, and extracted weight.

Trained Sensory Panels

From each loin, chop 8 (approximately 18 cm posterior to the spinalis dorsi muscle) was used for trained sensory testing. Testing consisted of a 6-member panel of students and staff selected from a pool of experienced and trained panelist at the University of Illinois. Panelists were trained for tenderness, juiciness, and pork flavor. Tenderness and juiciness training was completed by cooking several different pork chops (enhanced and not enhanced) to different degrees of doneness (145 °F - medium-rare, 160 °F - medium, and 176 °F - well-done) and as a collective group, panelists determined a respective anchor. Chops were assigned to sensory sessions using an incomplete randomized block schedule of chops for each sensory panel, generated using the OPTEX procedure in SAS (SAS Inst. Inc., Cary, NC). Chops for sensory evaluation were allowed to thaw for 24 h prior to each panel evaluation by placing the vacuum-packaged chops in a refrigerator at 4°C. Panelists were placed in individual, breadbox-style booths with red lights to mask color differences between samples. Tenderness, juiciness, and flavor were measured on a 15-cm anchored scale (0 = extremely tough, extremely dry, or no pork flavor and 15 = extremely tender, extremely juicy, or very intense pork flavor). Each panelist received unsalted saltine crackers and apple juice for palate cleansing between samples. To follow the recent cooking guidelines published by the National Pork Board, all chops were cooked to a medium-rare degree of doneness (63°C) with a 3-min rest after reaching the final internal temperature using a Farberware Open Hearth grill (model 455N; Walter Kidde, Bronx, NY). Internal temperature was monitored during cooking using copper-constantan thermocouples (Type T; OMEGA Engineering, Stamford, CT) placed in the geometrical center of each chop and connected to a digital scanning thermometer (model 92000-00; Barnant Co., Barrington, IL). Chops were cooked on one side to an internal temperature of 31°C, flipped, and then cooked until they reached an internal temperature of 63°C. Immediately after reaching 63°C internal temperature, chops were removed from the grill. At the conclusion of the 3-min rest period, subcutaneous fat and edges were removed from each chop and the remaining portion was cut using a sample sizer into approximately 1-cm cubes that did not contain visible connective tissue. Panelists were each given 2 cubes per sample on a paper plate. Each testing day consisted of 2 sessions with, at most, 8 samples per session. The study consisted of 18 sampling days and 278 samples. Sessions were held at least 1 h apart to reduce sensory fatigue. Results from all 6 panelists were averaged for use in data analyses.

Consumer Taste and Visual Appearance Panels

The procedures used in this study were approved by the Kansas State University Institutional Review Board. Loins were fabricated at 7, 8, and 9 d postmortem (32 to 36 loins/group/d). Prior to fabrication, loins were weighed in the package to obtain an initial weight and were reweighed after unpackaging to determine the amount of purge lost during storage. After unpackaging, loins were allowed 30 min for oxygenation before instrumental color readings were collected on the ventral side of the loin using a Hunter Lab Miniscan spectrophotometer (Illuminant A, 1-incm aperture, 10° observer, Hunter Lab Associates Laboratory, Reston, VA). Additionally, a trained Kansas State University research team member assessed each loin for subjective color and marbling according to the National Pork Producers Council subjective pork quality standards. Three pH readings were taken using a pH meter (HI 99163, Hanna Instruments, Smithfield, RI) at the anterior, middle, and posterior portions of loins and averaged to produce a single value for each loin. Loins were then cut immediately posterior to the spinalis dorsi and the posterior end of the loin was used for all analyses. Loins were fabricated and one, 1-inch chop from each loin was assigned to consumer taste panels. Chops were then vacuum packaged and frozen after 10 d of aging.

Consumer Taste Panels Consumers (n = 197) used for sensory evaluation were recruited from Manhattan, KS, and the surrounding areas and paid for their participation. Sensory panels took place in a lecture style classroom at Kansas State University. Each panelist was provided with a napkin, plastic fork, expectorant cup, and apple juice, water, and saltine crackers to use as palate cleansers. Chops were thawed at 35 to 40°F for 24 h prior to panels. Chops were cooked on clam-shell style grills (Cuisinart Griddler Deluxe, East Windsor, NJ) to a peak temperature of 160°F, with temperatures monitored using a Thermapen thermometer (Model Mk4; ThermoWorks, American Fork, UT). Chops were cut into 0.4 inch × 0.4 inch × chop thickness cuboids and 2 cuboids were served to each panelist.

Each panelist evaluated 8 samples (2/treatment) and recorded ratings on an electronic tablet (Model 5709 HP Stream 7; Hewlett-Packard, Palo Alto, CA) using a digital survey (Version 2417833; Qualtrics Software, Provo, UT). Panelists evaluated each sample for juiciness, tenderness, flavor like, and overall like on continuous line scales anchored at both ends and midpoints with 0 = extremely dry, extremely tough, dislike extremely, 50 = neither like nor dislike, neither tough nor tender, neither dry nor juicy, neither flavorful nor unflavorful, and 100 = extremely juicy, extremely tender, extremely flavorful, like extremely. Additionally, consumers were asked to rate each trait as acceptable or unacceptable with yes/no questions and to rate their perceived quality level of each sample as either unsatisfactory quality, everyday quality, better than everyday quality, or premium quality.

Consumer Visual Appearance Panels Panelists (n = 393) were recruited from Manhattan, KS, and the surrounding areas. Panels were conducted in the Kansas State University Color Laboratory. Panelists were provided an electronic tablet (Model 5709 HP Stream 7; Hewlett-Packard, Palo Alto, CA) with a digital survey (Version 2417833; Qualtrics Software, Provo, UT) to evaluate chops. Appearance and purchase intent were evaluated on continuous line scales with anchors at 1 (extremely undesirable/extremely unlikely to purchase), 50 (neither desirable or undesirable/would neither purchase or not purchase), and 100 (extremely desirable/extremely likely to purchase). Additionally, consumers rated each chop as overall desirable or undesirable (yes/no), and if they would or would not purchase the individual chop. Each panel consisted of 8 panelists. Labeled and unlabeled chops were displayed at 30 to 40°F in two separate coffin-style retail cases (model DMF8; Tyler Refrigeration Corp., Niles, MI) under fluorescent lights to mimic a retail experience. After instructions, panelists were taken to the retail case containing the 16 unlabeled packages (one from each weight treatment × thickness combination). The order in which chops were viewed by consumers was randomly assigned by the survey program. After completing evaluation of the first case of unlabeled packages, consumers were directed to proceed to the second case containing labeled packages, with the paired chops from the unlabeled evaluations.

Myosin Heavy Chain Fiber Type Determination

Loins were targeted from pigs that were slaughtered on the same day (day 1) and from the live phase treatment groups that were designed to not limit growth rate. Upon arrival, samples were excised from the loin with muscle fiber running parallel to each other, frozen in liquid nitrogen-cooled isopentane and stored at -80ºC. Samples were cut to 10-µm- thick sections on a cryostat (Reichert-Jung Cryocut 1800, Leica Microsystems Inc., Buffalo Grove, IL). A total of 2 consecutive sections for each sample were placed on separate glass slides and held at -80 °C for further analysis. Immunofluorescence was used to distinguish skeletal muscle fiber types. Slides were first blocked with a 10% normal goat serum for 60 minutes at about 24 °C. Primary antibodies (Developmental Hybridoma Bank, Iowa City, IA) of unique antibody isoform structure targeted myosin heavy chain (MHC) isoforms 1 (BA-F8, IgGb2, 1/50) and 2a/X (SC-71, IgG1, 1/100) were used on slide A and 1/2a (BF-35, IgG1, 1/100) and 2b (BF-F3, IgM, 1/10) were used on slide B. Secondary antibodies conjugated to 3 distinct Alexa Fluor (Life Technologies) dyes differentiated fiber types (A-21145, Alexa Fluor 594, 1/100; A-21121, Alexa Fluor 488, 1/100; A-21426, Alexa Fluor 555, 1/100) were used between both slides with slide A having Alexa Fluor 594 and 488 and slide B having Alexa Fluor 488 and 555. Slides were rinsed in three 1X PBS (Phosphate Buffered Saline 10X; BioWittaker Lonza, Switzerland) washes after each incubation step. An Advanced Microscopy Group Evos Florescent Microscope (model AMF-4306-US; Life Technologies) with total magnification of 295X was used to visualize florescence and capture 3 representative images from each section that were used to determine fiber type composition and fiber type cross-sectional area (CSA). Cells were traced on Adobe Photoshop (Adobe Systems Inc.) to determine average CSA for each fiber type.

Statistical Analysis

For the live portion of the experiment, data were analyzed as a randomized complete block design using the PROC GLIMMIX procedure of SAS (version 9.4, SAS Institute, Inc., Cary, NC) with pen considered the experimental unit and location as blocking factor. Linear and quadratic contrasts were applied for the four treatments without topping strategies. The LSMEANS statement was used to separate the two topping strategies from each other and the treatment was stocked at 7.7 ft2/pig with only one marketing event. These comparisons were utilized to understand differences between the multiple marketing treatments to the treatment with the most similar initial stocking density, as these three treatments are the most representative of industry floor space allowance and marketing strategies currently utilized. Results were considered significant at $P \leq 0.05$.

Summary statistics were calculated using PROC MEANS of SAS. Predictive ability of HCW was calculated for each dependent variable using the regression procedure of SAS (version 9.4; SAS Inst. Inc., Cary, NC). Coefficients of determination (R^2) and the slope of each regression line determined to predict trends in quality attributes were considered significantly different from 0 at $P \leq 0.05$.

For the consumer panel, statistical analysis was performed using the PROC GLIMMIX procedure of SAS (SAS Version 9.4; SAS Inst. Inc., Cary, NC). Loin was used as the experimental unit and the 4 weight groups as treatments. Sensory panel data were evaluated as a completely randomized design with panel session included as a random effect. For all acceptability and data, a model with binomial error distribution was used. For all analyses, the Kenward-Roger approximation was used and α was set at 0.05.

Results: Report your research results by objective.

Objective 1:

Table 1. Initial space allowance and removal strategy

Initial floor space, ft^2	12.7	10.4	8.8	7.7	7.1[2]	7.7[3]
Final floor space, ft^2	12.7	10.4	8.8	7.7	10.4	10.4
Initial pigs/pen:	14	17	20	23	25	23
Marketing events	1	1	1	1	4	3
Removals						
d 93	---	---	---	---	3	---
d 108	---	---	---	---	---	To common inventory of 20
d 122	---	---	---	---	To common inventory of 20	---
d 147	---	---	---	---	To common inventory of 17	To common inventory of 17
d 160	- all remaining pigs -					

[1]A total of 976 finishing pigs (initially 48 ± 3.4 lb BW) were used in a 160-d experiment to evaluate the effects of pig space allowance and marketing strategy on finishing pigs raised to heavier weights.

[2]Three pigs/pen were topped on d 93 to provide 8.0 ft^2/pig, topped to a common inventory of 20 pigs/pen on d 122 to provide 8.8 ft^2/pig, and a common pen inventory of 17 pigs/pen on d 147 to provide 10.4 ft^2/pig.

[3]Pens were topped to a common inventory of 20 pigs/pen on d 108 to provide 8.8 ft^2/pig and a common inventory of 17 pigs/pen on d 147 to provide 10.4 ft^2/pig.

Table 2. Diet composition, phases 1 through 6[1]

	Dietary phase					
Ingredient, %	1	2	3	4	5	6
Corn	39.39	47.08	55.49	60.74	60.52	82.76
Soybean meal, 46.5% crude protein	17.40	9.80	6.58	6.52	6.92	14.62
Corn DDGS[2]	40.00	40.00	35.00	30.00	30.00	---
Monocalcium phosphate, 21% P	0.20	0.15	0.10	0.10	0.09	0.50
Limestone	1.30	1.25	1.20	1.20	1.15	0.78
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Copper sulfate	0.03	0.03	0.03	---	---	---
L-Lysine-HCl	0.58	0.63	0.55	0.45	0.40	0.30
DL-Methionine	0.02	---	---	---	0.00	0.05
L-Threonine	0.09	0.09	0.07	0.05	0.04	0.12
L-Tryptophan	0.04	0.05	0.04	0.04	0.04	0.03
Premix[3]	0.20	0.20	0.20	0.15	0.10	0.10
Phytase[4]	0.08	0.08	0.10	0.10	0.10	0.10
Sodium metabisulfite	0.15	0.15	0.15	0.15	0.15	0.15
Starter premix[5]	0.05	---	---	---	---	---
Total	100	100	100	100	100	100
Calculated analysis						
Standardized ileal digestible (SID) amino acids, %						
Lysine	1.18	1.03	0.88	0.78	0.76	0.77
Isoleucine:lysine	63	59	60	64	67	61
Leucine:lysine	166	172	183	194	203	149
Methionine:lysine	31	30	32	34	36	34
Methionine and cysteine:lysine	56	56	60	64	67	61
Threonine:lysine	62.0	60.7	60.7	63.0	64.9	67.6
Tryptophan:lysine	18.3	18.3	17.8	19.3	19.7	19.7
Valine:lysine	74	72	75	80	84	70
Total lysine	1.39	1.22	1.05	0.94	0.91	0.88
SID lysine:net energy ratio, g/Mcal	4.94	4.24	3.56	3.15	3.04	3.06
Net energy, kcal/lb	1,082	1,104	1,120	1,128	1,128	1,149
Crude protein, %	22.9	20.1	17.8	16.7	16.9	14.0
Calcium, %	0.63	0.58	0.54	0.53	0.51	0.45
Phosphorus, %	0.50	0.46	0.42	0.40	0.40	0.42
Available phosphorus, %	0.27	0.25	0.21	0.19	0.19	0.16

[1]Diets were fed in six phases from 48 to 70, 70 to 120, 120 to 180, 180 to 230, 230 to 270, and 270 lb until the end of the study.

[2]DDGS = dried distillers grains with solubles. Provided 700,000 IU vitamin A from vitamin A acetate, 200,000 IU vitamin D from vitamin D_3, 3,650 IU vitamin E from dl-α-tocophorol acetate, 400 mg menadione from menadione nicotinamide bisulfite, 3.6 mg B_{12} from cyanocobalamin, 6,800 mg niacin from niacinamide, 3,000 pantothenic acid from d-calcium panthothenate, 900 mg riboflavin from crystalline riboflavin, 1.4 g Cu from copper sulfate, 72.7 mg Ca from calcium iodate, 14 mg Fe from ferrous sulfate, 1.5 g Mn from manganese sulfate, 54.5 mg Se from sodium selenite, and 14 g Zn from zinc sulfate.

[3]Ronozyme HiPhos (GT) 2700 (DSM Nutritional Products, Parsippany, NJ) provided 1,102,300 phytase units (FTU)/kg of product with a release of 0.10% available P.

[4]Provided 850,000 IU vitamin A from vitamin A acetate, 250,000 IU vitamin D from vitamin D_3, 9,090 IU vitamin E from dl-α-tocophorol acetate, 450 mg menadione from menadione nicotinamide bisulfite, 5 mg B_{12} from cyanocobalamin, 7,500 mg niacin from niacinamide, 4,000 pantothenic acid from d-calcium

panthothenate, 1,200 mg riboflavin from crystalline riboflavin, 30 mg biotin, 300 mg folic acid, 200 mg pyridoxine from pyridoxine HCl, 750 mg thiamin from thiamin hydrochloride, 1.7 g Cu from copper sulfate, 100 mg Ca from calcium iodate, 16 mg Fe from ferrous sulfate, 4.0 g Mn from manganese sulfate, 45.5 mg Se from sodium selenite, and 16 g Zn from zinc sulfate.
[5]NRC. 2012. Nutrient requirements of swine. 11th ed. Natl. Acad. Press, Washington, DC.

Table 3. Effects of space allowance and marketing strategy on growth performance of pigs raised to heavy market weights[1]

Initial floor space, ft^2/pig:	12.7	10.4	8.8	7.7	7.1[2]	7.7[3]		*P*-value	
Final floor space, ft^2/pig:	12.7	10.4	8.8	7.7	10.4	10.4		Fixed inventory floor space[4]	
Initial pigs/pen:	14	17	20	23	25	23			
Marketing events:	1	1	1	1	4	3	SEM	Linear	Quadratic
BW, lb									
d 0	48.9	48.7	49.0	48.8	48.0	48.3	1.26	0.994	0.926
d 93	239.7	234.2	232.7	230.9	227.6	228.2	3.29	0.008	0.610
d 108[a]	264.9	257.1	255.9	254.9	246.8	251.2	3.09	0.005	0.276
d 122	296.4	287.5	286.2	283.6	277.2	275.8	3.19	0.002	0.397
d 135	325.6	315.5	313.3	309.0	303.5	303.8	2.96	0.001	0.527
d 147	351.5	341.9	339.9	333.9	332.3	330.2	3.22	0.001	0.814
d 160	377.3	368.6	364.9	358.5	353.4	356.4	3.50	0.001	0.925
d 0 to 93									
ADG, lb	2.04	1.99	1.97	1.96	1.92	1.92	0.025	0.002	0.450
ADFI, lb	5.22	5.04	4.98	4.99	4.83	4.87	0.070	0.003	0.191
F/G	2.57	2.54	2.53	2.55	2.51	2.54	0.019	0.321	0.165
d 93 to 108									
ADG, lb	1.66	1.48	1.51	1.57	1.70	1.51	0.069	0.230	0.057
ADFI, lb	5.86	5.53	5.51	5.57	5.45	5.39	0.109	0.026	0.086
F/G[a,c]	3.59	3.78	3.65	3.58	3.25	3.62	0.139	0.878	0.139
d 108 to 122									
ADG, lb	2.25	2.09	2.08	2.04	2.13	2.10	0.052	0.005	0.342
ADFI, lb	7.92	7.18	7.20	7.04	7.14	7.17	0.129	0.001	0.054
F/G	3.52	3.45	3.47	3.46	3.35	3.433	0.0765	0.585	0.659
d 122 to 135									
ADG, lb[a,b]	2.26	2.15	1.99	1.95	2.12	2.12	0.072	0.001	0.917
ADFI, lb	7.99	7.54	7.39	7.22	7.44	7.42	0.110	0.001	0.459
F/G	3.57	3.54	3.75	3.75	3.53	3.50	0.106	0.073	0.513
d 135 to 147									
ADG, lb[a,b,c]	2.16	2.20	2.21	2.02	2.41	2.21	0.063	0.208	0.064
ADFI, lb[a,b]	8.12	7.87	7.56	7.27	7.87	7.77	0.114	0.001	0.199
F/G[a,c]	3.76	3.59	3.45	3.63	3.28	3.52	0.083	0.070	0.121
d 147 to 160									
ADG, lb	1.98	2.05	1.93	1.84	1.90	2.16	0.105	0.145	0.183
ADFI, lb[b]	8.40	8.18	7.84	7.66	8.01	8.32	0.256	0.001	0.583

F/G	4.28	4.03	4.09	4.18	4.33	3.86	0.145	0.580	0.212
d 0 to 160									
ADG, lb	2.04	1.98	1.95	1.92	1.96	1.95	0.017	0.001	0.713
ADFI, lb	6.20	5.91	5.82	5.77	5.64	5.72	0.069	0.001	0.169
F/G[a,b,c]	3.04	2.99	2.98	3.00	2.87	2.94	0.021	0.091	0.040
Adjusted F/G[5]	2.59	2.58	2.60	2.65	2.60	2.62	0.022	0.053	0.055
Performance during topping events									
d 93 to 160									
ADG, lb[a,b]	2.05	1.97	1.93	1.87	2.03	1.99	0.028	0.001	0.941
ADFI, lb	7.60	7.18	7.03	6.90	7.07	7.06	0.084	0.001	0.314
F/G[a,b]	3.70	3.65	3.65	3.69	3.48	3.56	0.042	0.665	0.143
Removals, %	2.6	7.2	7.3	5.8	7.8	7.4	2.4	0.182	0.131
Total weight gain, lb/pen	4,458	4,979	5,778	6,581	6,582	6,328	210.4	0.001	0.042
Total weight gain, lb/pig[a,b,c]	327[a]	316[b]	312[b,c]	306[c]	288[e]	298[d]	3.0	0.001	0.810

BW = body weight. ADG = average daily gain. ADFI = average daily gain. F/G = feed efficiency.

[a]Pigs stocked at 7.7 ft^2/pig with one marketing event vs. pigs initially stocked at 7.1 ft^2/pig with 4 marketing events are significantly different ($P < 0.05$).

[b]Pigs stocked at 7.7 ft^2/pig with one marketing event vs. pigs initially stocked at 7.7 ft^2/pig with 3 marketing events are significantly different ($P < 0.05$).

[c]Pigs stocked at 7.1 ft^2/pig with 4 marketing events vs. pigs initially stocked at 7.7 ft^2/pig with 3 marketing events are significantly different ($P < 0.05$).

[1]A total of 976 finishing pigs (initially 58 ± 3.4 lb BW) were used in a 160-d experiment to evaluate the effects of pig space allowance and marketing strategy on finishing pigs raised to heavier weights.

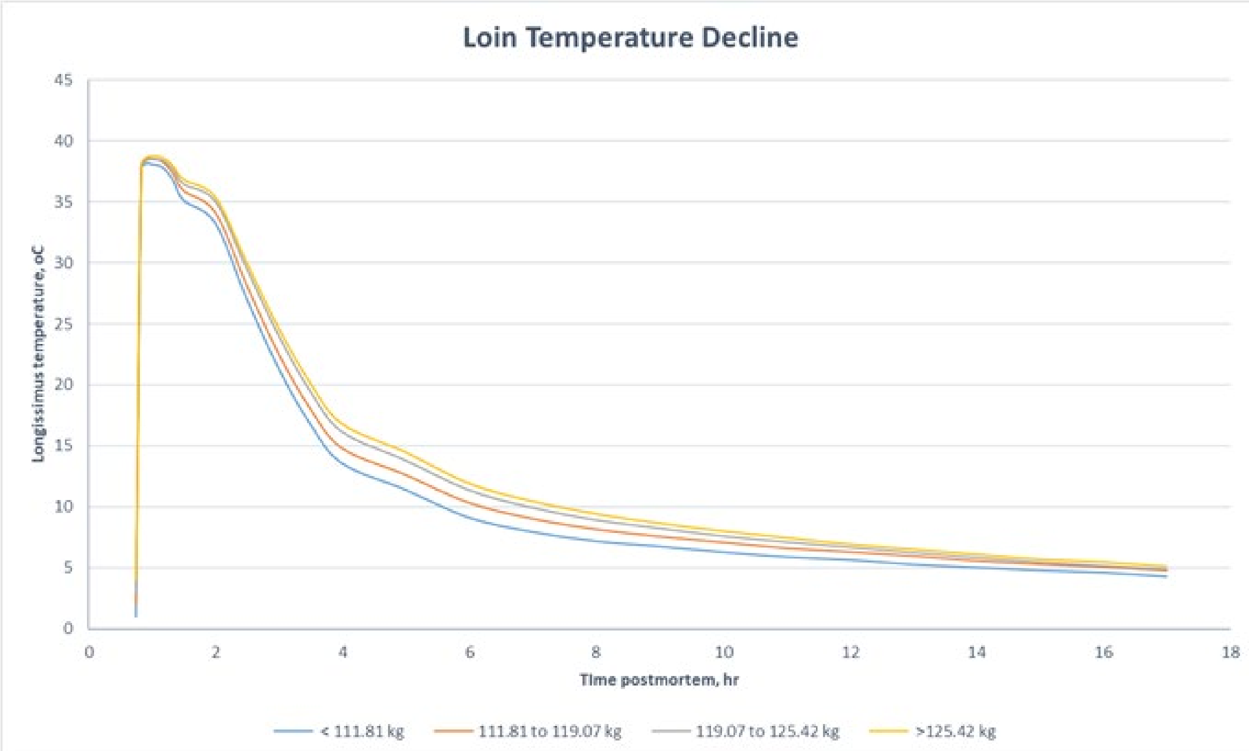
[2]Three pigs/pen were topped on d 93 to provide 8.0 ft^2/pig, topped to a common inventory of 20 pigs/pen on d 122 to provide 8.8 ft^2/pig, and a common pen inventory of 17 pigs/pen on d 147 to provide 10.4 ft^2/pig.

[3]Pens were topped to a common inventory of 20 pigs/pen on d 108 to provide 8.8 ft^2/pig and a common inventory of 17 pigs/pen on d 147 to provide 10.4 ft^2/pig.

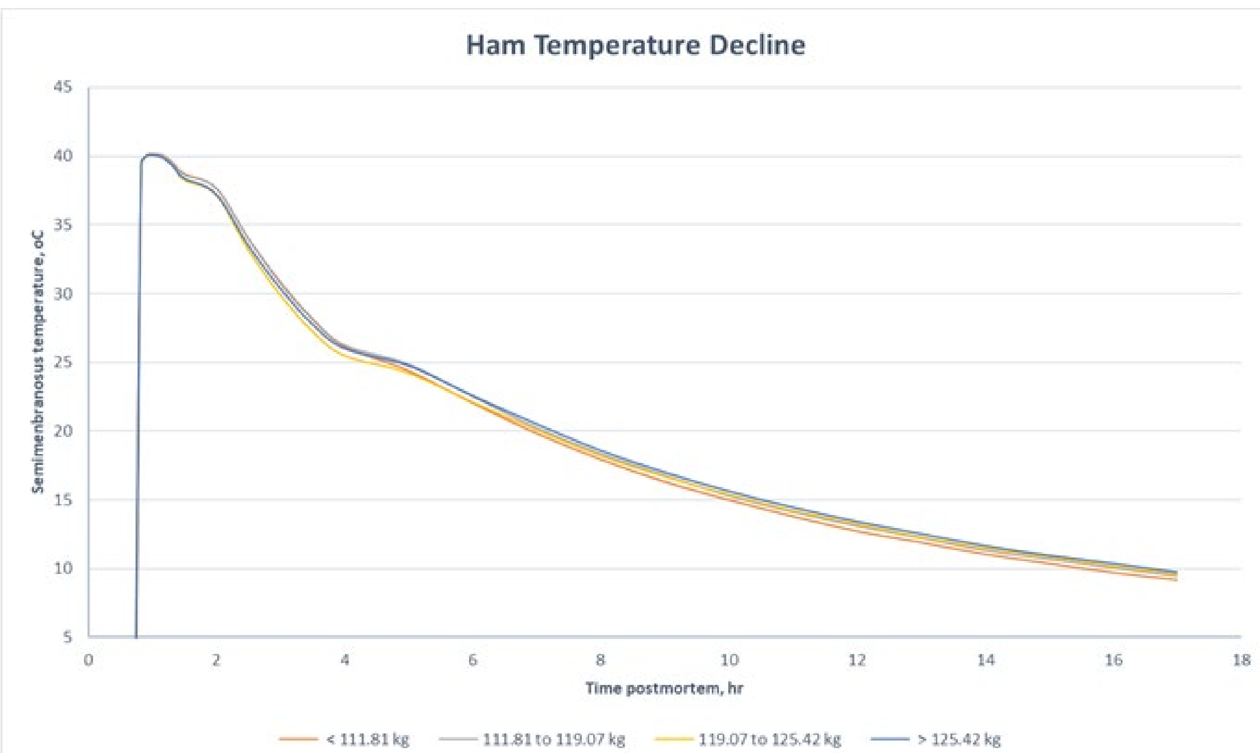
[4]Treatments 1 through 4 that did not employ topping were evaluated using linear and quadratic contrasts.

[5]Calculated as adjusted F/G = [285 − final BW] × 0.0048 + actual overall F/G.

Objective 2:



lb),
276.5 lb).



(LT =
HVY =
> 276.5 lb).

Objective 3:

Table 4. Population summary statistics of carcass characteristics

Variable	Number	Mean	Minimum	Maximum	SD	CV
Hot carcass weight, kg	666	118.8	78.46	145.12	10.47	44.56
Fat depth, mm	612	16.18	7.6	27.6	3.12	19.26
Loin depth, mm	612	67.64	45.2	89.6	7.25	10.71
Estimated lean, %	612	53.19	48.41	58.3	1.61	3.02
Iodine value	591	69.5	58.74	81.93	3.74	5.37
Ham, kg	203	13.98	10.93	16.96	1.29	9.25
% of HCW	203	23.38	20.08	27.14	1.20	5.13
Boneless loin, g	613	4665.59	3188	6602	539.40	11.56

Table 5. Population summary statistics of early and aged ham and loin quality

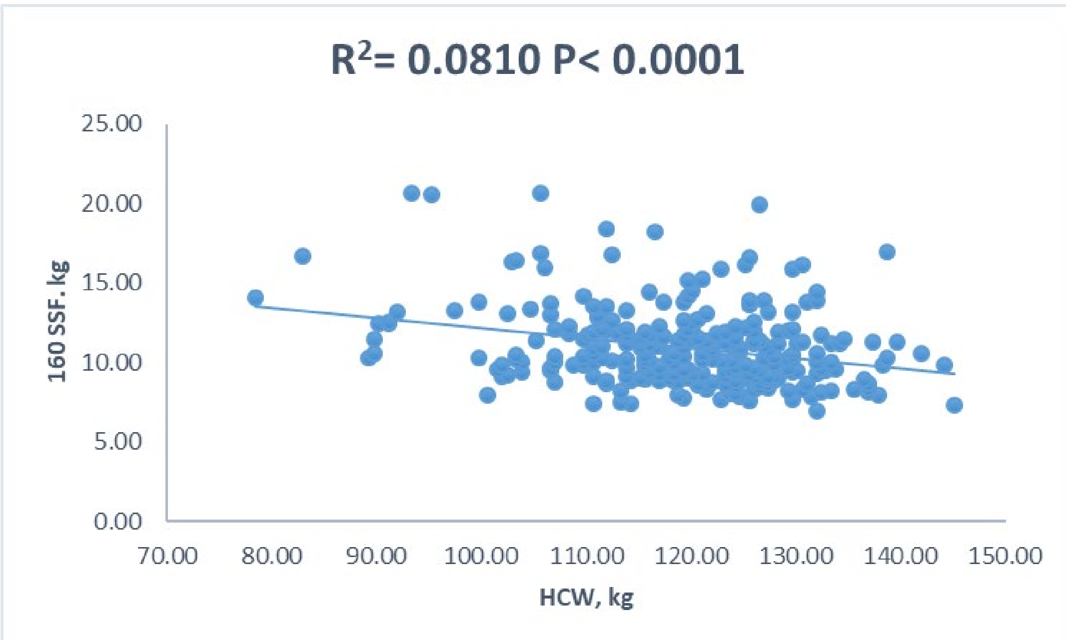
Variable	Number	Mean	Minimum	Maximum	SD	CV
Ham Quality						
Instrumental Color[1]						
L*	203	44.83	36.95	58.5	3.12	6.96
a*	203	10.05	6.37	14.43	1.56	15.51
b*	203	1.84	-2.18	5.82	1.52	82.78
Gluteus Medius pH	202	5.67	5.25	6.13	0.13	2.29
Loin Quality						
1-d pH	613	5.69	5.49	6.66	0.11	2.00
1-d Instrumental Color[1]						
L*	613	54.2	47.11	63.47	2.26	4.18
a*	613	8.32	5.35	12.06	1.02	12.21
b*	613	13.43	10.37	15.93	0.85	6.33
1-d NPPC visual quality[2]						
Color	613	3.32	2	5	0.61	18.31
Marbling	613	2.15	1	6	0.9	41.99
Firmness	613	1.94	1	4	0.77	32.11
14-d purgeloss, %	276	1.05	-0.02	3.29	0.57	54.14
Average Chop, g	276	240.79	161.25	304.68	26.36	10.95
Chop Quality						
14-d pH	276	5.51	5.18	6.35	0.15	2.66
14-d NPPC visual quality[2]						
Color	276	3.02	1.5	5	0.43	14.35
Marbling	276	1.54	1	3	0.32	20.67
Firmness	276	2.9	2	3	0.21	7.25
160 Slice Shear Force, kg	276	10.95	6.92	20.67	2.46	22.50
145 Slice Shear Force, kg	276	10.35	7.04	16.51	1.62	15.67
160 Cook Loss, %	276	18.09	13.3	23.94	1.43	7.89
145 Cook Loss, %	276	12.49	9.18	17.15	1.05	8.44
Moisture, %	278	73.92	70.79	76.61	0.7	0.95
Fat, %	278	2.12	0.47	5.78	0.81	38.20

[1]L* measures darkness to lightness (greater L* value indicates a lighter color). a* measures redness (greater a* value indicates a redder color). b* measures yellowness (greater b* value indicates a more yellow color).
[2]NPPC color using the 1999 standards, half point scale where 1 = visually palest; and 6 = visually darkest. NPPC marbling using the 1999 standards where 1 = visually the least marbling and 6 = visually the most marbling. NPPC firmness using the 1991 standard where 1 = softest and 6 = firmest.

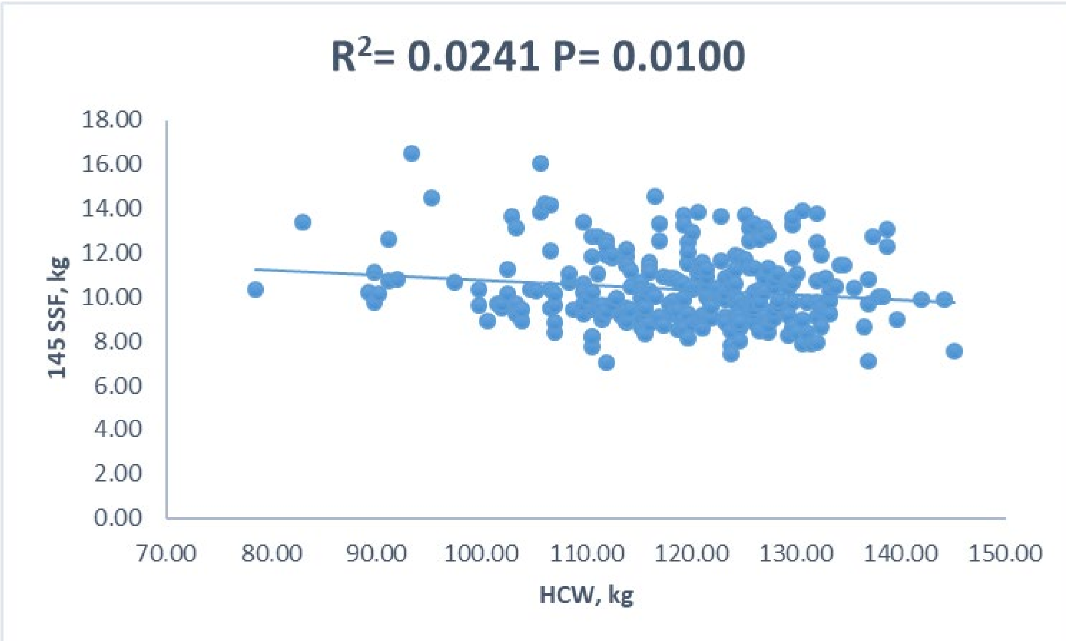
Table 6. Population summary statistics of trained sensory characteristics on a 15 pt. scale

Variable	No.	Mean	Minimum	Maximum	SD	CV
Tenderness	278	9.62	6.87	11.83	0.77	8.05
Juiciness	278	9.08	6.92	10.78	0.65	7.21
Flavor	278	1.86	1.35	2.48	0.2	10.99

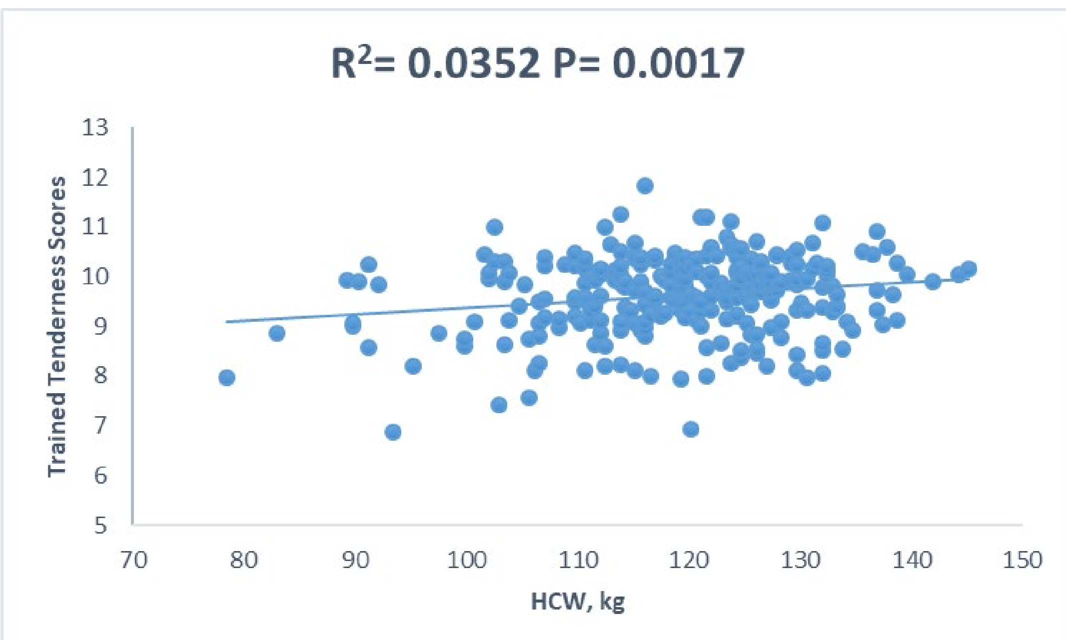
Sensory scores with a greater value represent a greater degree of tenderness, juiciness, or flavor



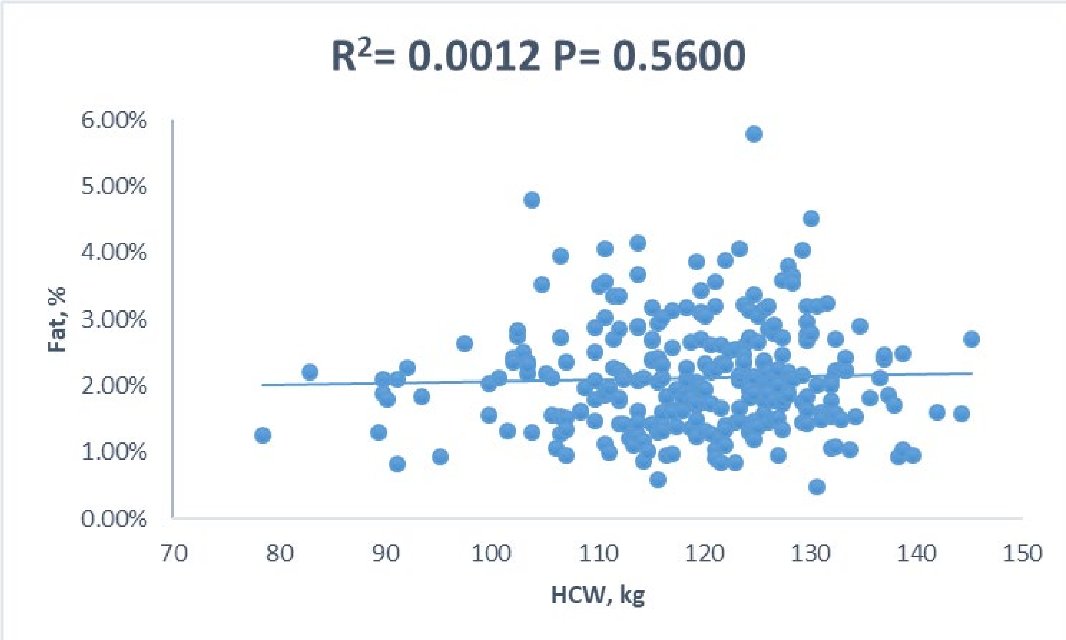
hear force of chops cooked to an internal temperature of 160°F. A greater number for slice shear force equates to less tender. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$)



hear force of chops cooked to an internal temperature of 145°F. A greater number for slice shear force equates to less tender. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).



pork chops cooked to an internal temperature of 145°F. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).



ps. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).

Objective 4:

Table 7. Least squares means for loin (n = 200) characteristics of 4 weight groupings of pork hot carcasses

Carcass weight[1]	Loin weight, lb	Purge loss, %[2]	L*[3]	a*[4]	b*[5]	Color score[6]	Marbling score[7]	pH
LT	8.8[a]	2.7	59.1	16.6	14.4	4.2	2.3	5.7
MLT	9.9[b]	2.6	59.5	16.4	14.3	4.3	2.4	5.7
MHVY	10.1[c]	2.6	58.7	16.9	14.5	4.2	2.2	5.7
HVY	10.8[d]	2.4	58.1	16.6	14.4	4.4	2.4	5.7
SEM[8]	0.13	0.16	0.33	0.18	0.16	0.10	0.08	0.01
P-value	< 0.01	0.48	0.38	0.27	0.82	0.29	0.26	0.35

[abcd]Least squares means in the same column without a common superscript differ ($P < 0.05$).

[1]LT = Light. MLT = medium-light. MHVY = medium-heavy. HVY = heavy. Carcass weight groups: LT = less than 246.5 lb, MLT = 246.5 to 262.5 lb, MHVY =262.5 to 276.5 lb, and HVY = 276.5 lb and greater.

[2]Purge loss = [1 – (loin weight / (initial weight – dry package weight)].

[3]L* (lightness; 0 = black and 100 = white).

[4]a* (redness; − 60 = green and 60 = red).

[5]b* (yellowness − 60 = blue and 60 = yellow).

[6]Color score: 1 = pale pinkish grey to white. 6 = dark purplish red.

[7]Marbling score: 1 to 10 according to the National Pork Board Marbling Standards.

[8]SEM (largest) of the least squares means in the same column.

Table 8. Least squares means for consumer (n = 197) palatability ratings[1] of pork top loin chops of varying hot carcass weight groups

Carcass weight[2]	Juiciness rating	Tenderness rating	Flavor rating	Overall like rating
LT	57.7	55.9[b]	58.7	59.0
MLT	60.3	60.6[a]	59.7	60.5
MHVY	59.6	60.5[a]	61.2	61.0
HVY	63.1	63.9[a]	62.2	64.3
SEM[3]	1.7	1.7	1.5	1.5
P-value	0.12	< 0.01	0.19	0.06

[ab]Least squares means in the same column without a common superscript differ (P < 0.05).

[1]Sensory scores: 0 = extremely dry/tough/dislike flavor/dislike overall; 100 = extremely juicy/tender/like flavor/overall like.

[2]LT = light. MLT = medium-light. MHVY = medium-heavy. HVY = heavy. Carcass weight groups: LT = less than 246.5 lb, MLT = 246.5 to 262.5 lb, MHVY = 262.5 to 276.5 lb, and HVY = 276.5 lb and greater.

[3]SEM (largest) of the least squares means in the same column.

Table 9. Least squares means for the percentage of consumers (n = 197) who indicated the sample was acceptable for juiciness, tenderness, flavor, and overall for varying hot carcass weight group

Carcass weight[1]	Juiciness acceptability	Tenderness acceptability	Favor acceptability	Overall acceptability
LT	78.5[b]	80.2[b]	82.9	80.2
MLT	80.7[b]	85.7[a]	83.7	83.6
MHVY	80.1[b]	86.8[a]	82.9	83.5
HVY	86.1[a]	89.7[a]	85.1	87.4
SEM[2]	1.6	1.8	1.6	0.2
P-value	0.04	< 0.01	0.81	0.07

[ab]Least squares means in the same column without a common superscript differ ($P < 0.05$).

[1]Carcass weight groups: LT = light. MLT = medium-light. MHVY = medium-heavy. HVY = heavy. Carcass weight groups: LT = less than 246.5 lb, MLT = 246.5 to 262.5 lb, MHVY = 262.5 to 276.5 lb, and HVY = 276.5 lb and greater.

[2]SEM (largest) of the least squares means in the same column.

Table 10. Least squares means for consumer (*n* = 197) ratings of pork top loin chops of varying hot carcass weight groups for perceived quality[1]

Carcass weight[2]	Unsatisfactory	Everyday quality	Better than everyday	Premium
LT	17.3[a]	48.7	25.6	7.6
MLT	14.1[ab]	48.3	26.6	10.1
MHVY	16.3[a]	47.1	24.3	11.2
HVY	10.6[b]	46.8	30.0	11.8
SEM[3]	0.2	0.1	0.1	0.2
P - value	0.04	0.94	0.34	0.20

[ab]Least squares means in the same column without a common superscript differ ($P < 0.05$).

[1]Percentage of each carcass weight group perceived as: unsatisfactory, everyday quality, better than everyday quality, and premium quality by consumers.

[2]Carcass weight groups: LT = light. MLT = medium-light. MHVY = medium-heavy. HVY = heavy. Carcass weight groups: LT = less than 246.5 lb, MLT = 246.5 to 262.5 lb, MHVY = 262.5 to 276.5 lb, and HVY = 276.5 lb and greater.

[3]SEM (largest) of the least squares means in the same column.

Table 11. Least squares means for consumer (n = 393) visual ratings for appearance and purchase intent for chops of various thicknesses from carcasses of various weight categories.

Treatment	Appearance rating[1]	Purchase intent rating[2]	Purchase % yes[3]
Carcass weight[4]			
LT	61.1[c]	58.9[c]	62.0
MLT	62.1[bc]	59.7[bc]	63.7
MHVY	63.1[ab]	60.9[ab]	65.9
HVY	64.5[a]	62.2[a]	66.8
SEM[5]	0.90	0.10	0.80
P - value	<0.01	<0.01	0.08
Chop thickness, inches			
0.50	54.8[c]	51.9[c]	45.9[d]
0.75	64.1[b]	63.2[ab]	71.5[b]
1.00	66.3[a]	64.3[a]	73.9[a]
1.25	65.7[a]	62.3[b]	65.0[c]
SEM[5]	0.80	0.91	0.77
P - value	<0.01	<0.01	<0.01
Package label[6]			
Labeled	62.8	60.2	63.2[b]
Unlabeled	62.7	60.7	66.0[a]
SEM[5]	0.74	0.84	0.66
P - value	0.83	0.36	<0.01

[abc]Least squares means lacking a common superscript within the same main effect (carcass weight, chop thickness, and package label) differ ($P < 0.05$).

[1]Consumer appearance and purchase intent ratings: 0 = extremely undesirable; 100 = extremely desirable.

[2]Consumer purchase intent ratings: 0 = extremely unlikely to purchase; 100 = extremely likely to purchase.

[3]Percentage of consumers who answered: indicated "Yes" they would purchase.

[4]LT = light. MLT = medium-light. MHVY = medium-heavy. HVY = heavy. Carcass weight groups: LT = less than 246.5 lb, MLT = 246.5 to 262.5 lb, MHVY = 262.5 to 276.5 lb, and HVY = 276.5 lb and greater.

[5]SEM (largest) of the least squares means.

[6]Package label: labeled contains price and weight information and unlabeled package.

Table 12. Carcass weight × chop thickness interaction ($P < 0.05$) for the percentage of consumers who indicated 'yes" the chop was desirable.

Chop thickness, in.	Carcass weight[1]			
	LT	MLT	MHVY	HVY
0.50	54.0[c]	55.9[c]	57.2[b]	61.8[c]
0.75	73.1[a]	73.6[a]	73.9[a]	70.3[b]
1.00	70.5[ab]	73.5[a]	73.6[a]	78.5[a]
1.25	65.8[b]	66.4[b]	71.6[a]	69.7[b]
SEM[2]	2.20	2.20	2.20	2.10
P - value	< 0.01	< 0.01	< 0.01	< 0.01

[abc]Least squares means lacking a common super script with in the same column differ ($P < 0.05$).

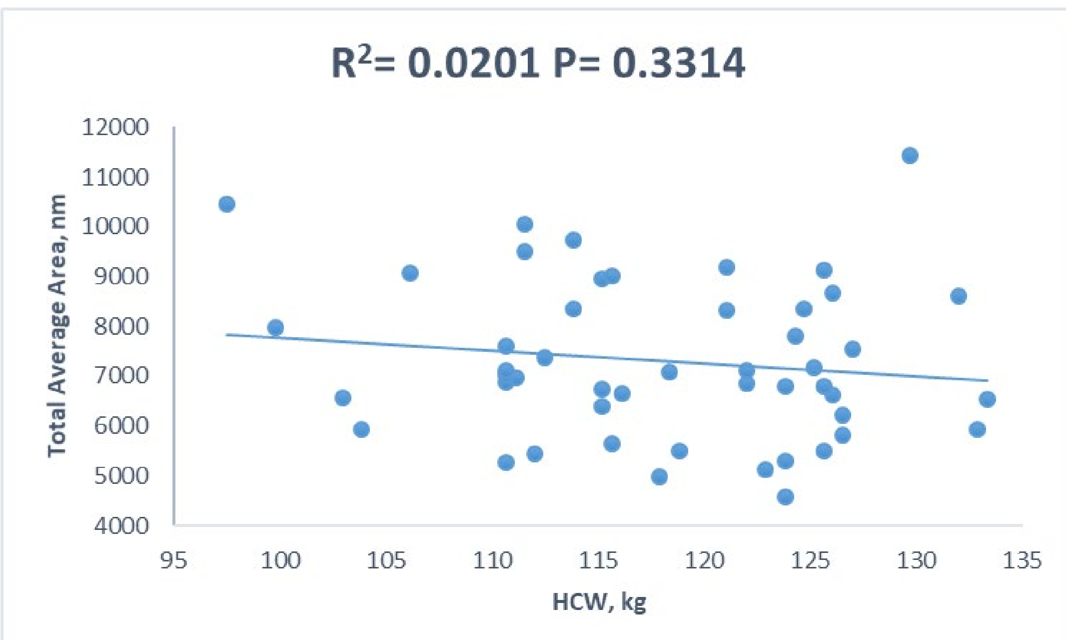
[1]LT = light. MLT = medium-light. MHVY = medium-heavy. HVY = heavy. Carcass weight groups: LT = less than 246.5 lb, MLT = 246.5 to 262.5 lb, MHVY = 262.5 to 276.5 lb, and HVY = 276.5 lb and greater.

[2]SEM (largest) of the least squares means.

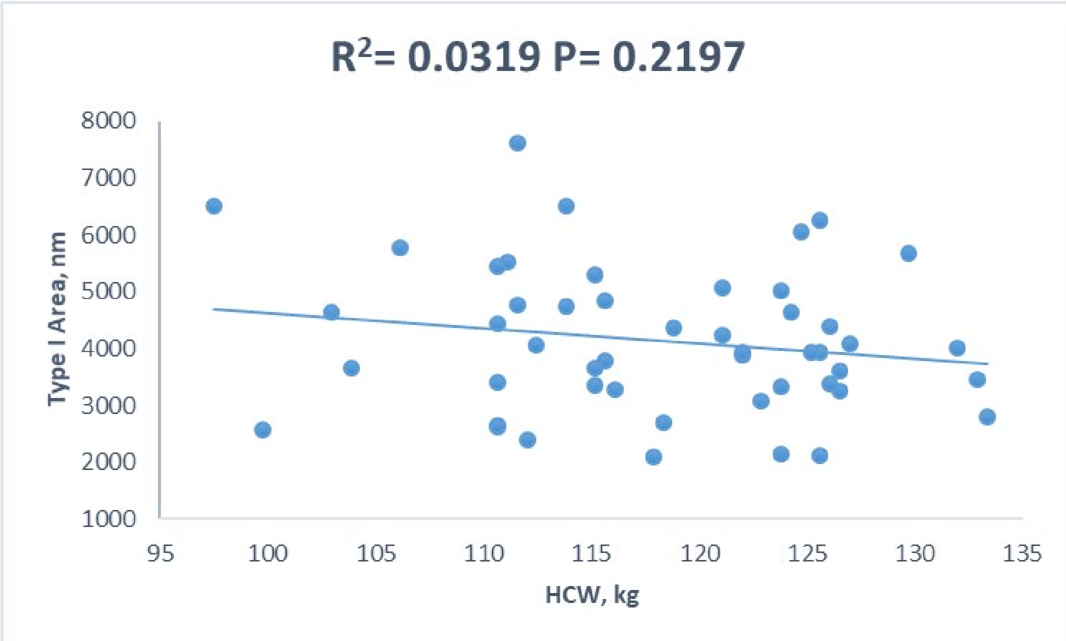
Objective 5:

Table 13. Population summary statistics of fiber type determination

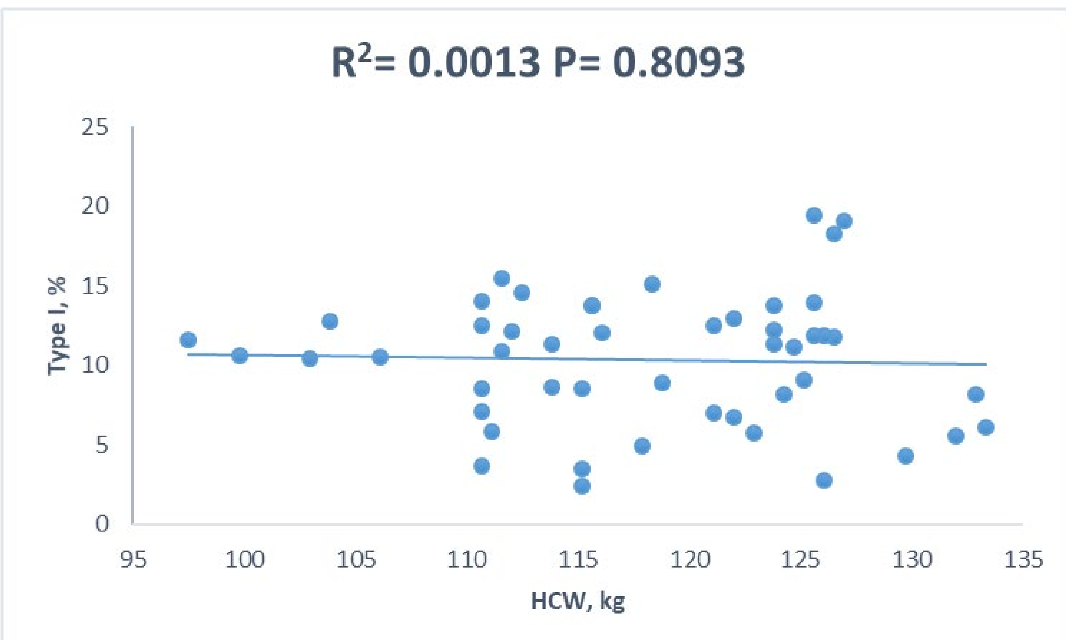
Variable	Number	Mean	Minimum	Maximum	SD	CV
Fiber type						
I, %	49	10.34	2.36	19.41	4.11	39.72
IIA, %	49	10.26	0.96	17.08	3.84	37.49
IIB, %	49	66.29	50	83.97	7.99	12.05
IIX, %	49	12.92	4.35	25.33	4.64	35.88
Fiber area, nm^2						
Total	49	7298.06	4577.31	11432.98	1572.81	21.55
I	49	4140.67	2087.02	7614.23	1272.08	30.72
IIA	49	4559.35	2476.14	8141.24	1331.41	29.20
IIB	49	8081.43	5331.61	12163.84	1740.55	21.54
IIX	49	8152.37	4674.21	15368.67	2377.34	29.16



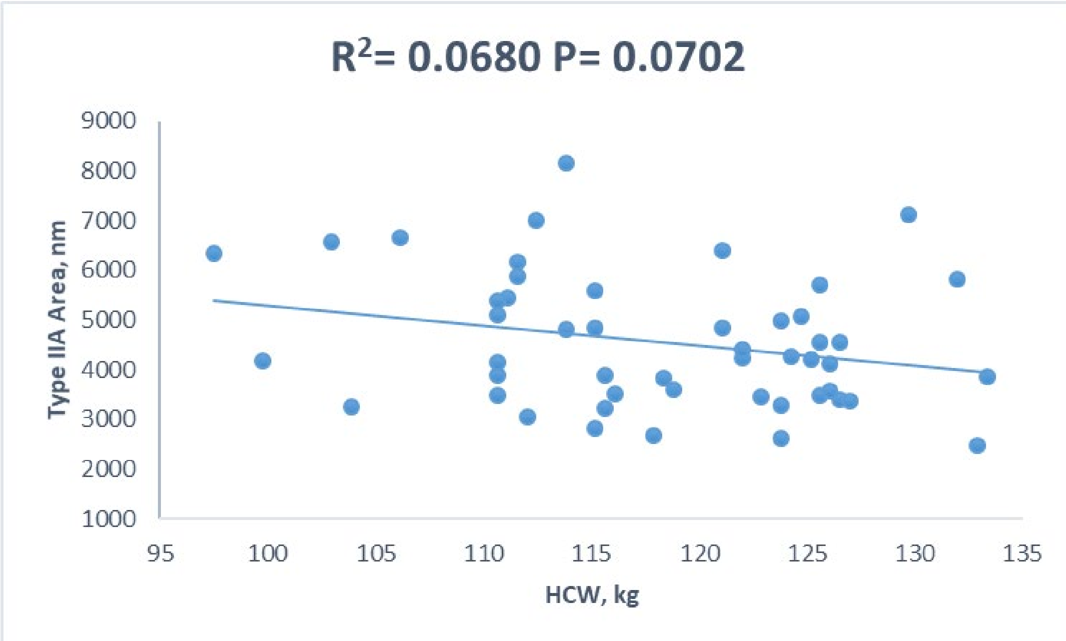
a are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



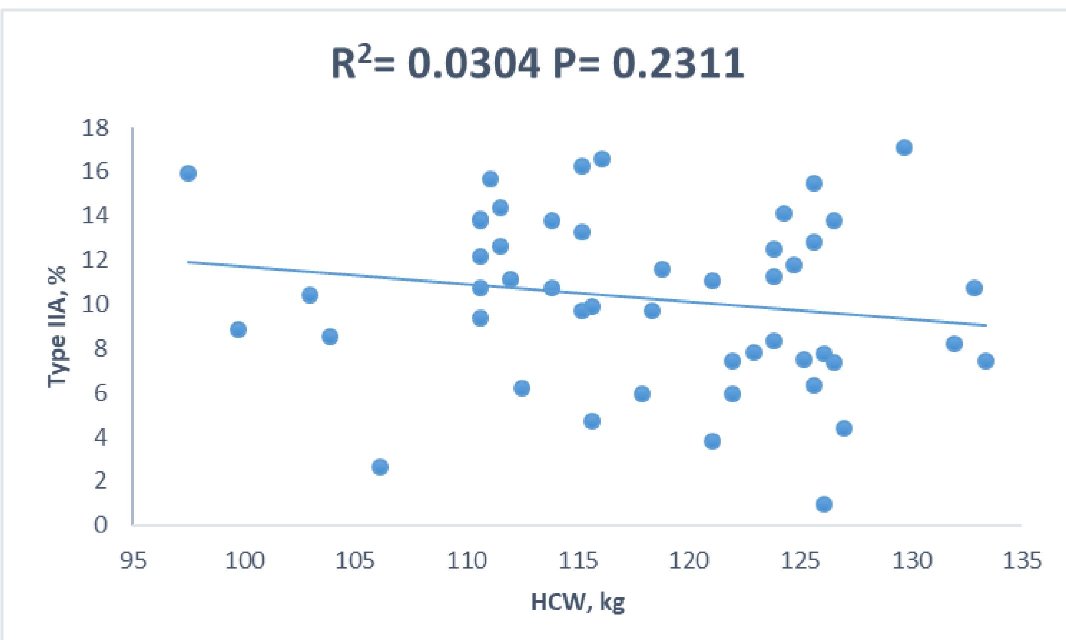
rs. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



rs. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



fibers. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



ibers. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).

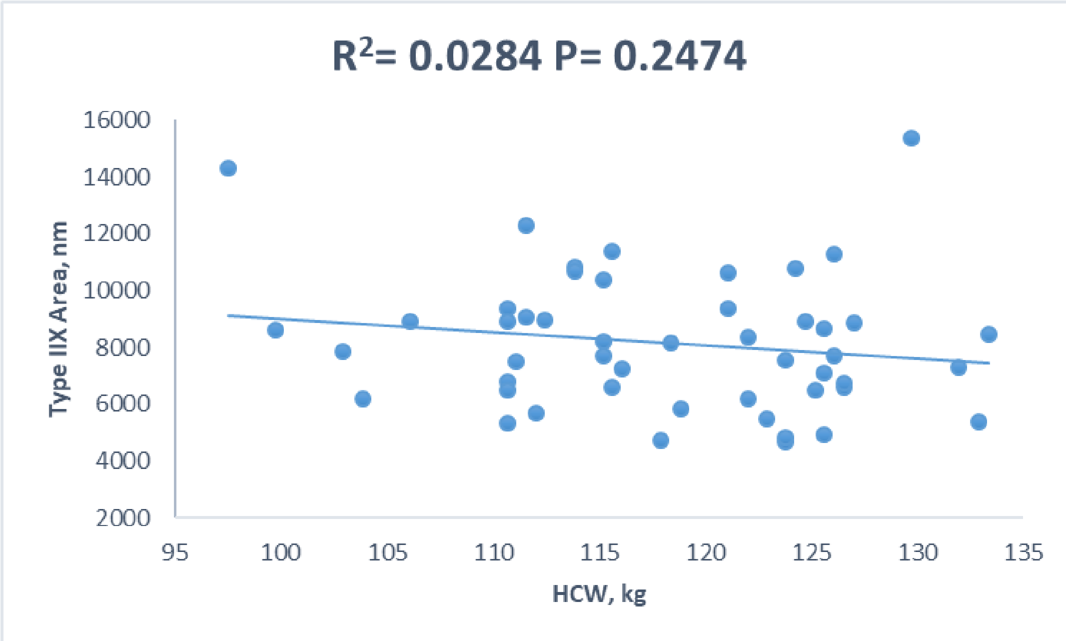


Figure 13. Effect of carcass weight (HCW) on the average area of Type IIX muscle fibers. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).

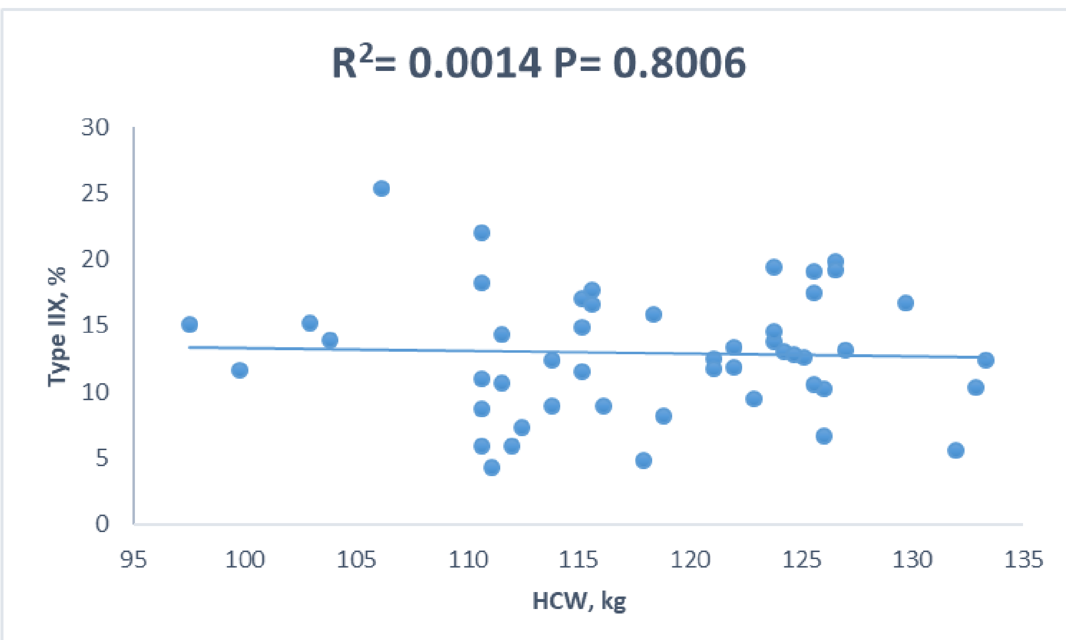
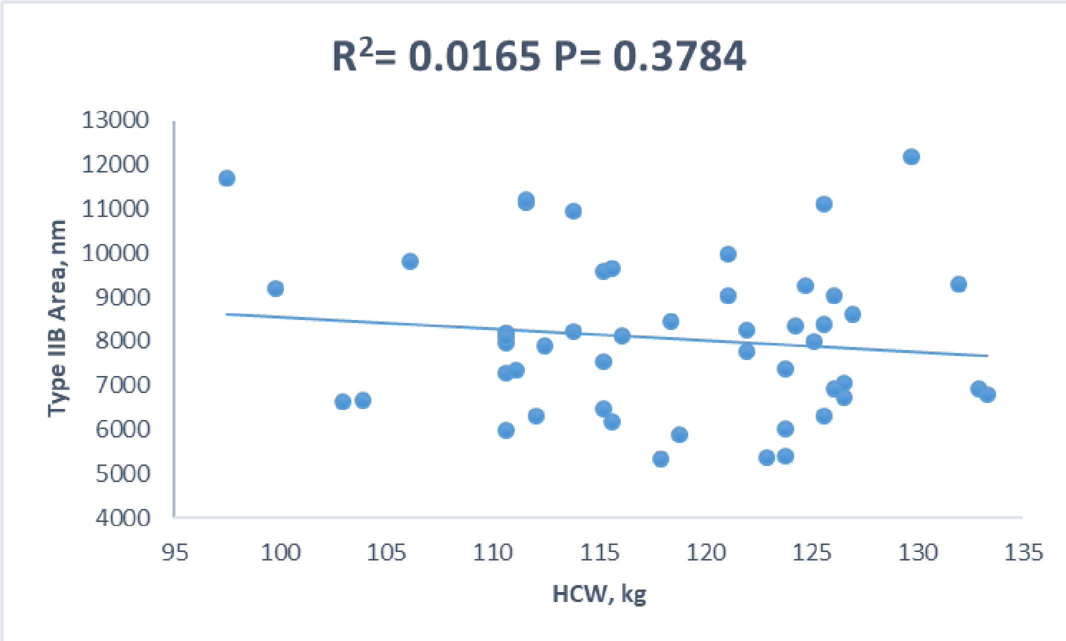
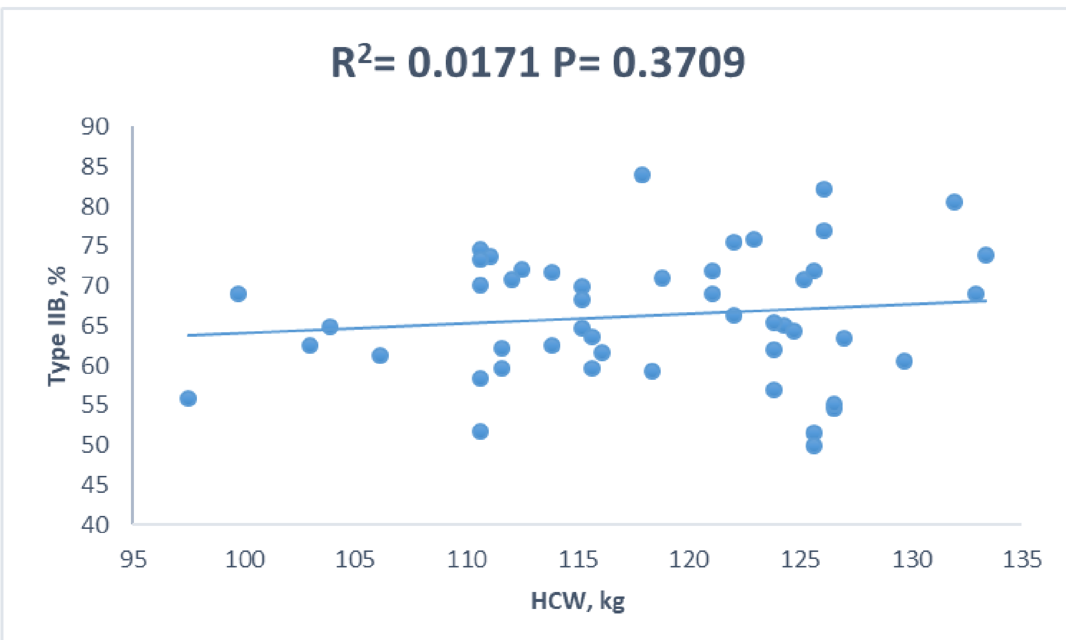


Figure 14. Effect of carcass weight (HCW) on the percentage of Type IIX muscle fibers. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients

of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



fibers. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



bers. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).

Discussion: Explain your research results and include a summary of the results that is of immediate or future benefit to pork producers.

Objective 1:

- When evaluating overall growth rates, it appears that the pigs used in this study had increasing ADG, albeit marginally, until approximately 340 lb BW before ADG started to decline
- Contrary to ADG, the feed intake of these pigs was still increased up to 360 lb BW which is generally consistent with literature
- Although ADG continued to increase until late in the study, F/G became poorer as BW increased, which is also expected
- Impact of reducing floor space allowance for pigs raised to heavy market weights is seen as early as 230 lb or before reaching the critical *k*-value
- A pig removal strategy via multiple marketing events may provide producers a means to maximize stocking density while mediating reduced performance

Objective 2:

- As carcasses get heavier, the temperature decline of hams and loins slowed

Objective 3:

- Increasing carcass weight will increase primal weights
- Tenderness is improved as carcass weight increases
- Chop WHC increases with heavier carcasses

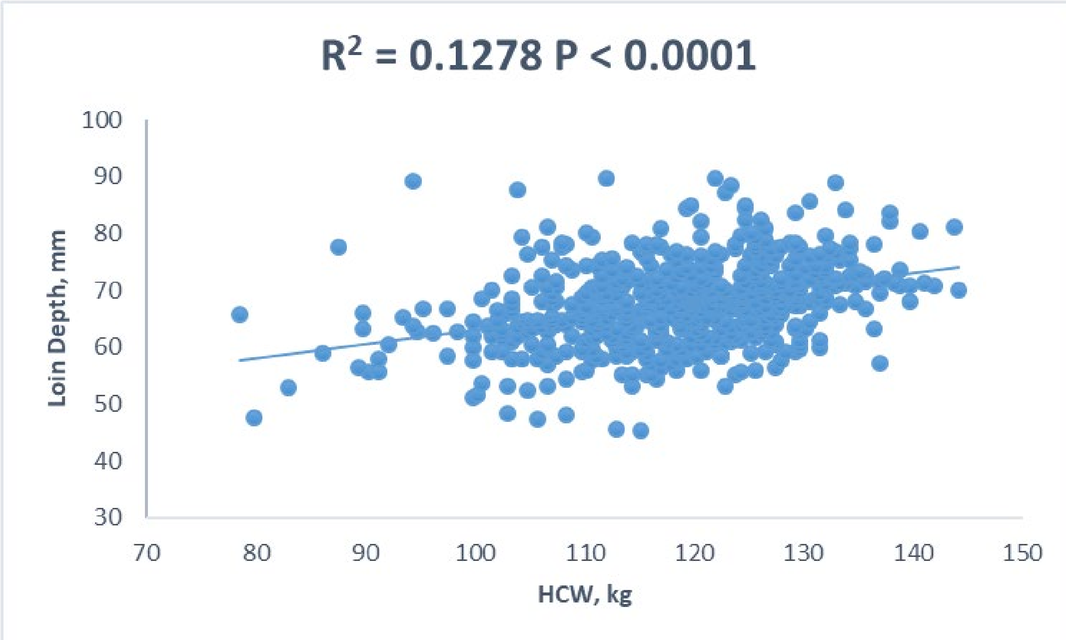
Objective 4:

- Increased hot carcass weight did not affect the color and marbling traits of the loins
- As hot carcass weights increase, there are no negative effects on loin quality and palatability characteristics.
- Tenderness was positively affected by increased weight; increasing the likelihood a consumer will have a satisfactory eating experience and thus encouraging repeat purchases.
- Carcass weight, chop thickness, and label type affected consumer overall desirability and purchase intent for fresh pork. Consumers indicated that chops from heavier carcasses and chops that were thicker were more desirable.
- However, as carcass weight increased, thicker chops became less desirable to consumers.
- Consumers were more likely to purchase chops with a thickness of 1.00 inch, indicating that chops could become too thick or too thin.
- Chops from heavy weight groups were not discriminated against due to increased price by our consumers.

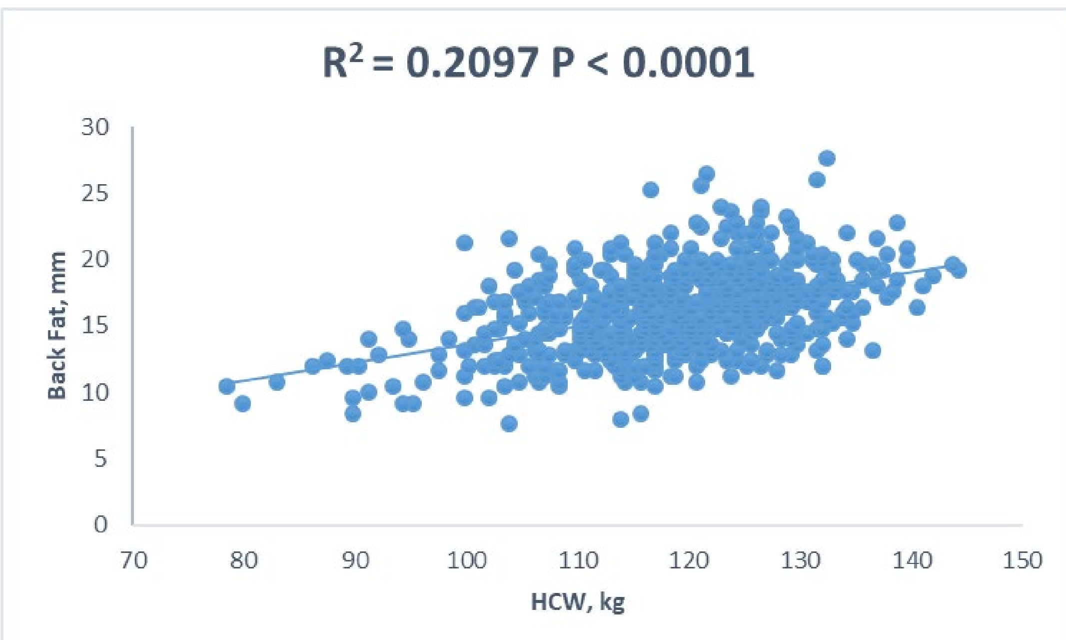
Objective 5:

- There is no significant difference in muscle type percentage or area between lighter and heavier pigs

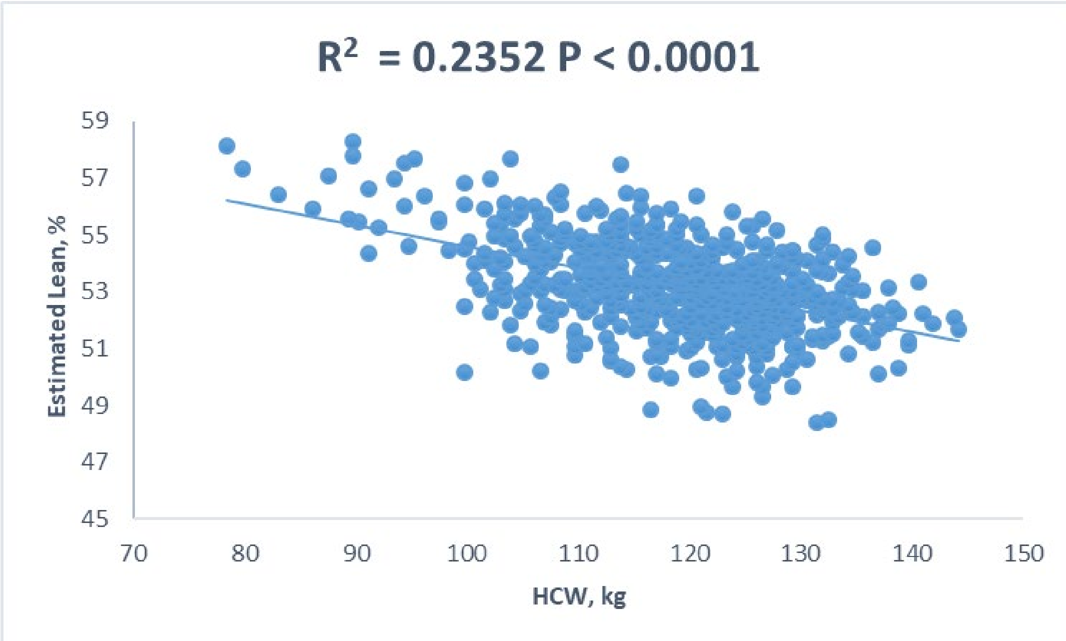
Appendix A: Regression figures



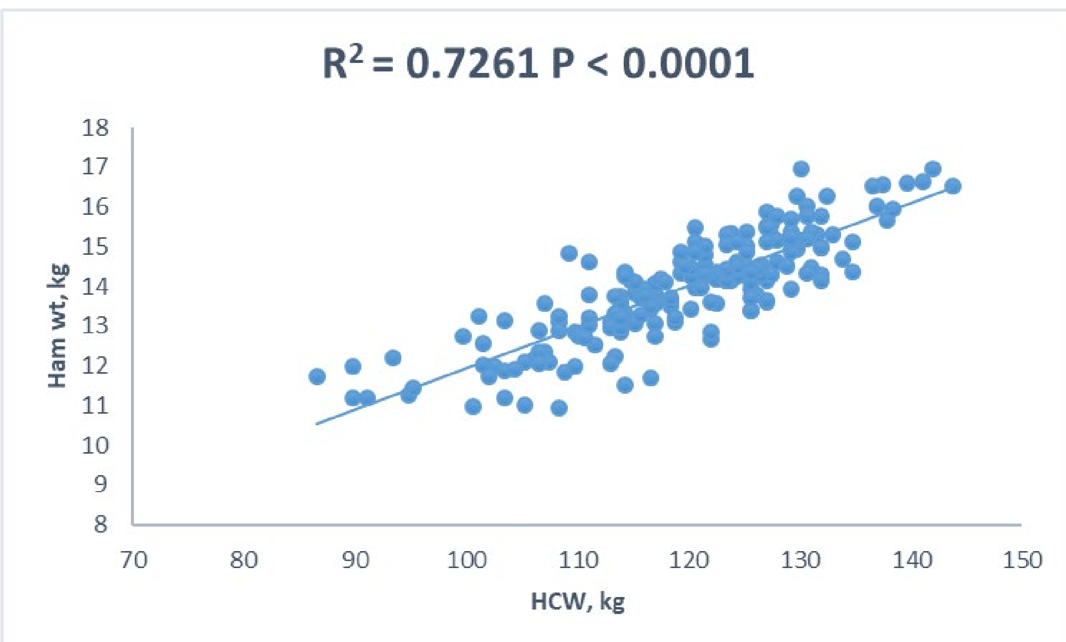
linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).



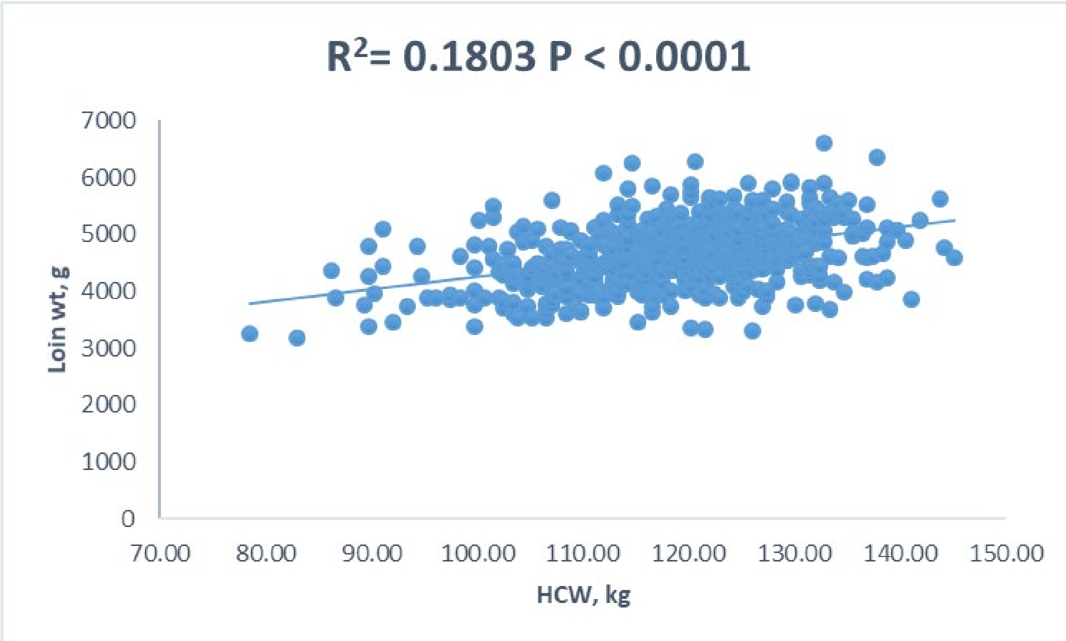
ted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).



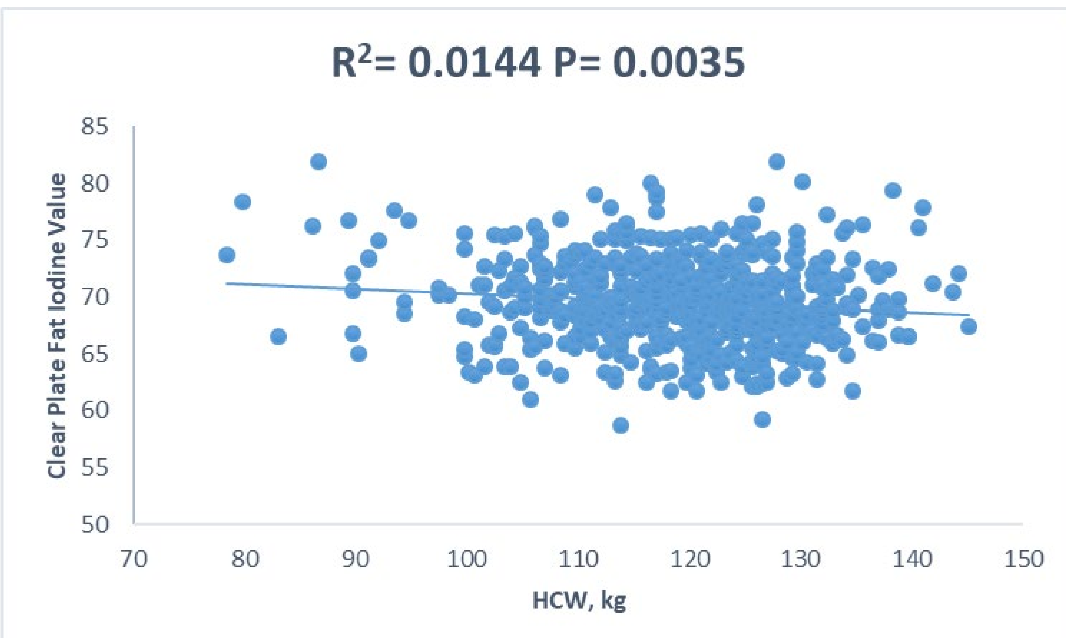
icted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).



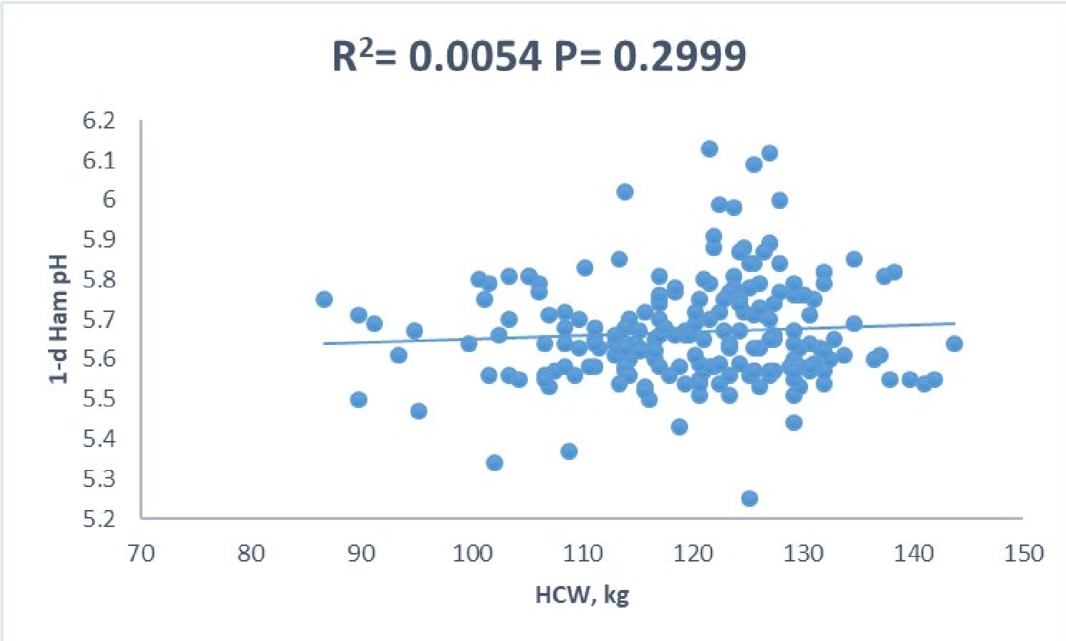
picted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).



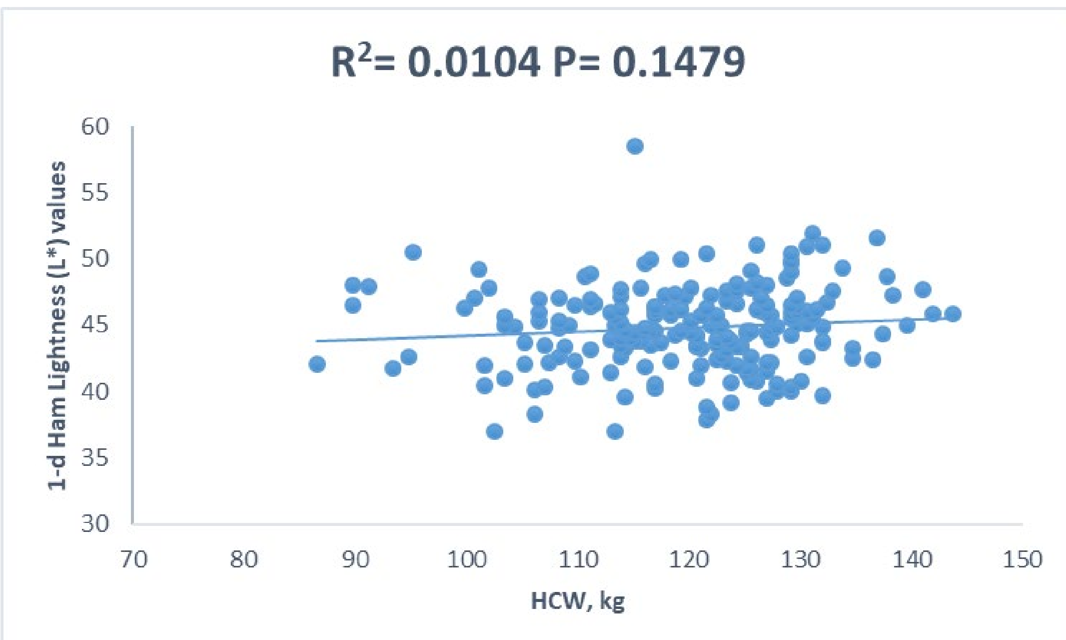
e depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).



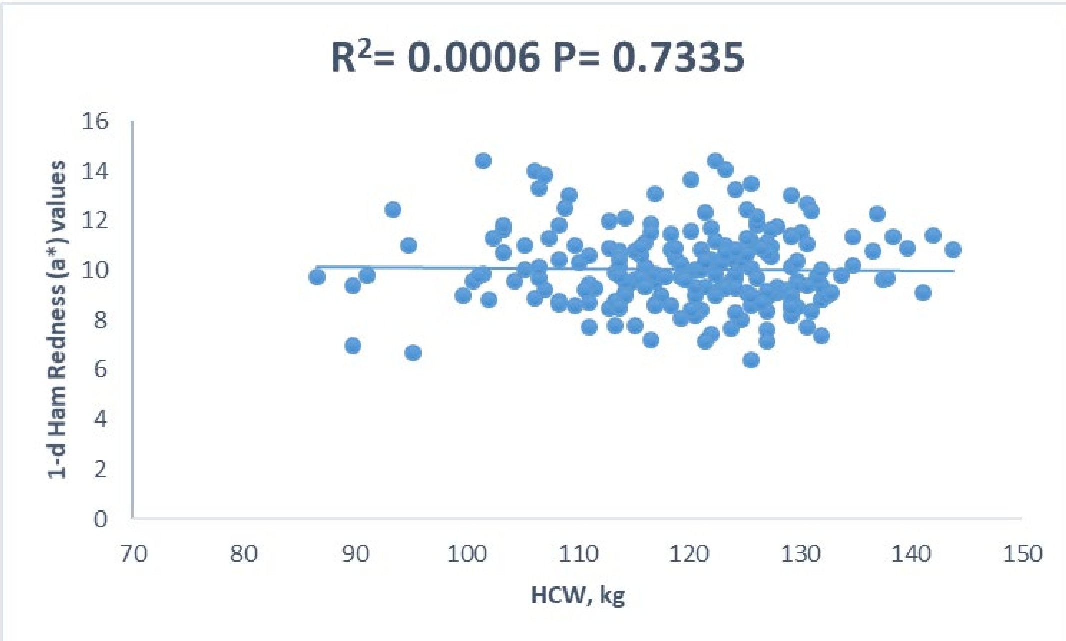
idline of the dorsal edge of the shoulder. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).



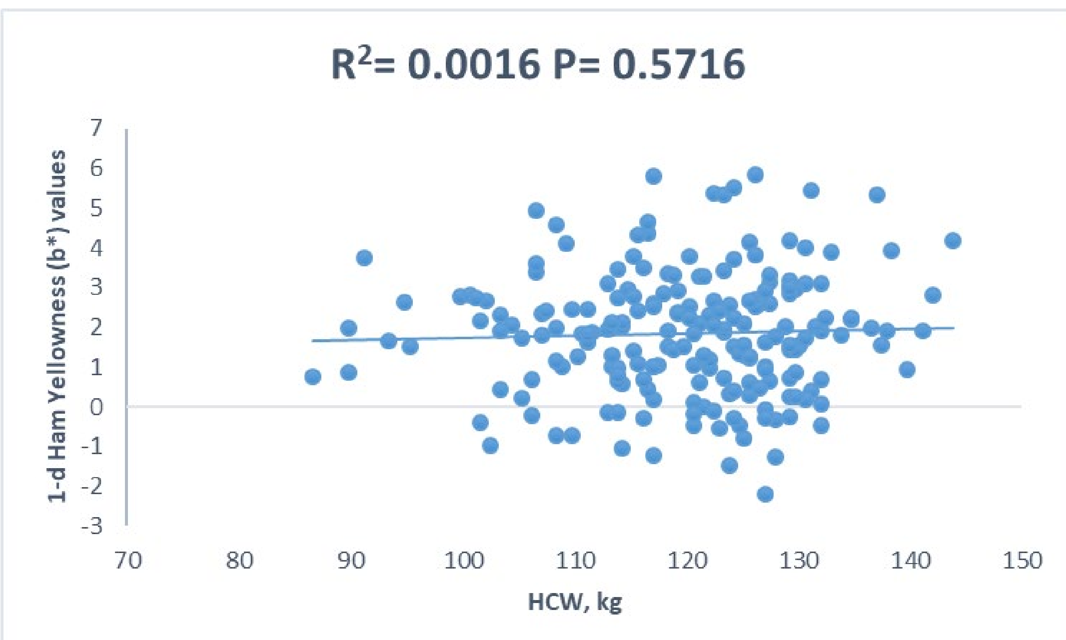
us ultimate pH. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



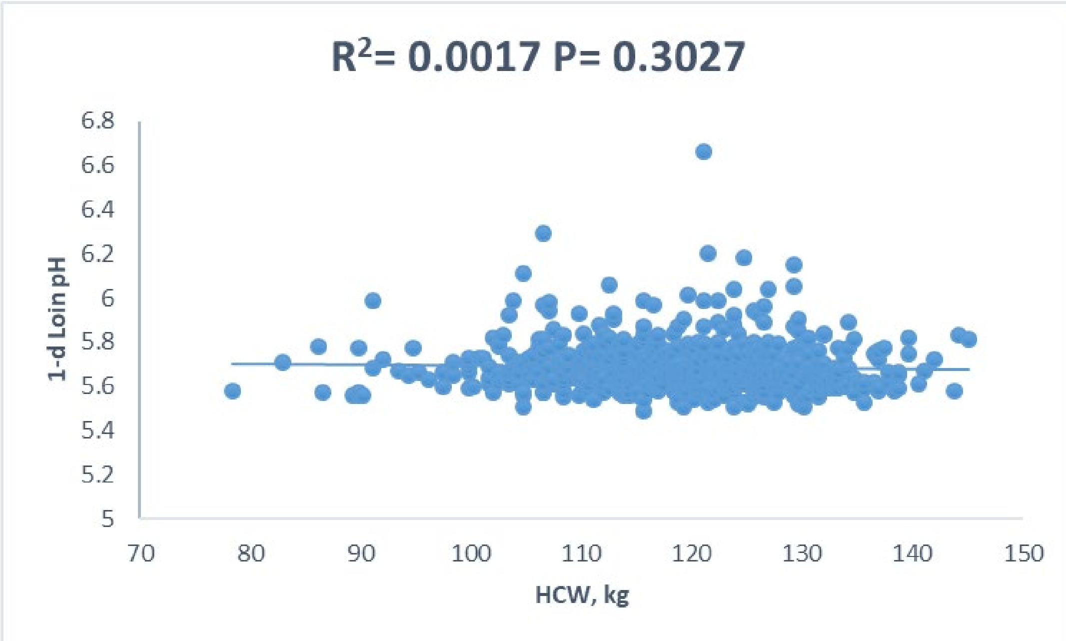
us instrumental lightness (CIE L*). Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



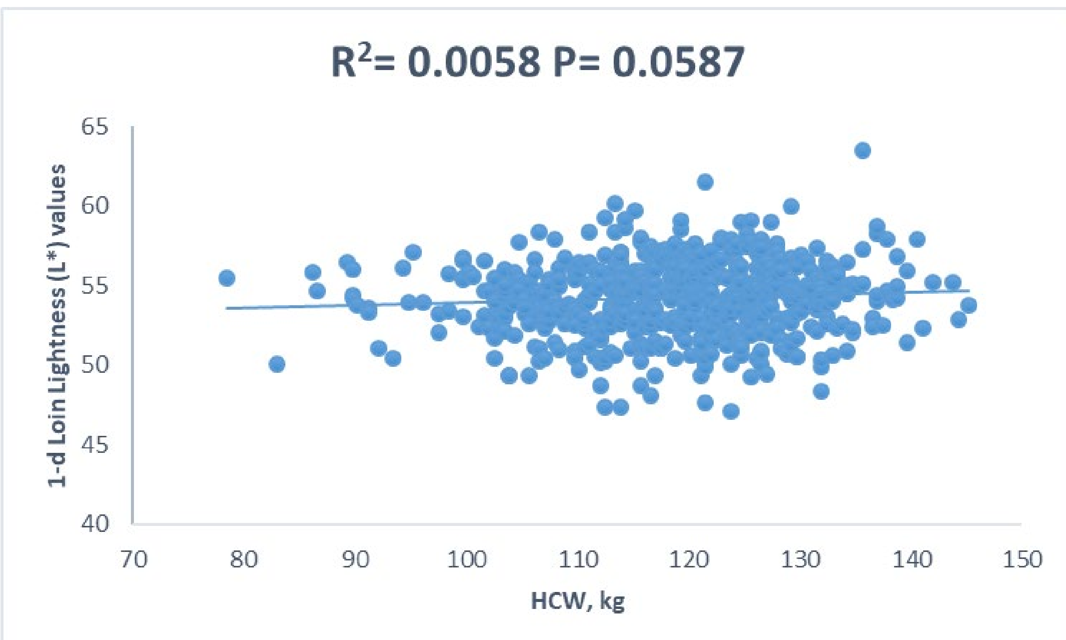
us instrumental redness (CIE a*). Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



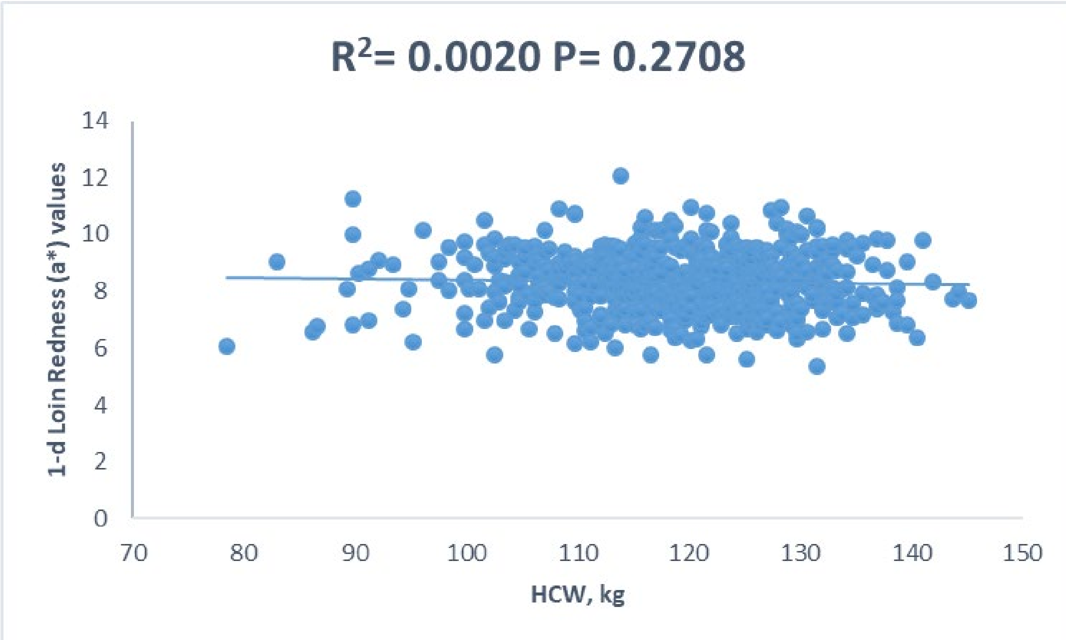
us instrumental yellowness (CIE b*). Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



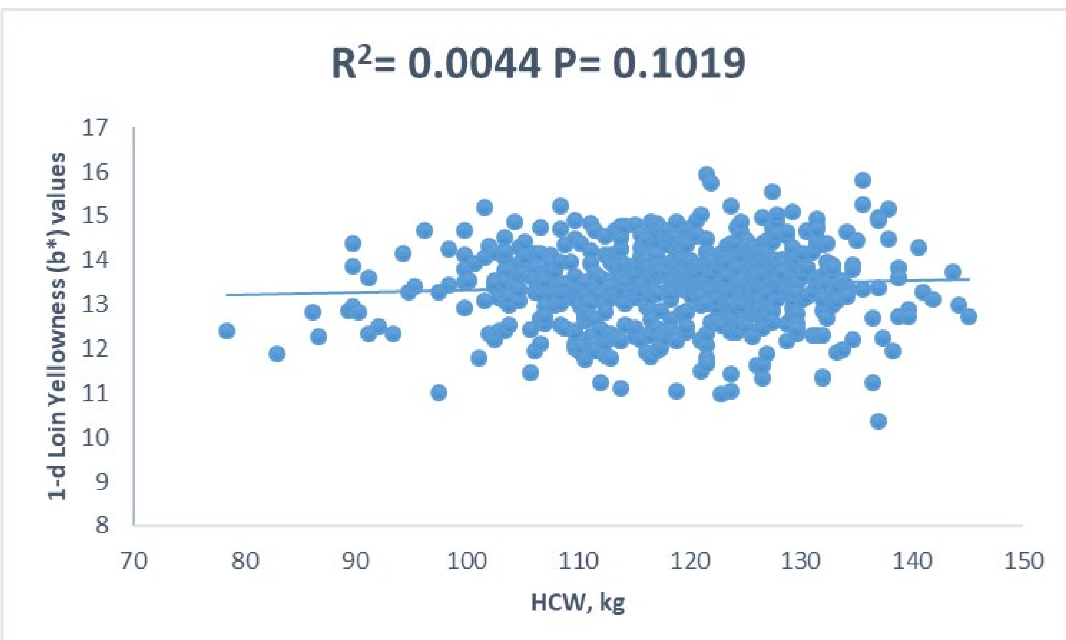
dorsi ultimate pH. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



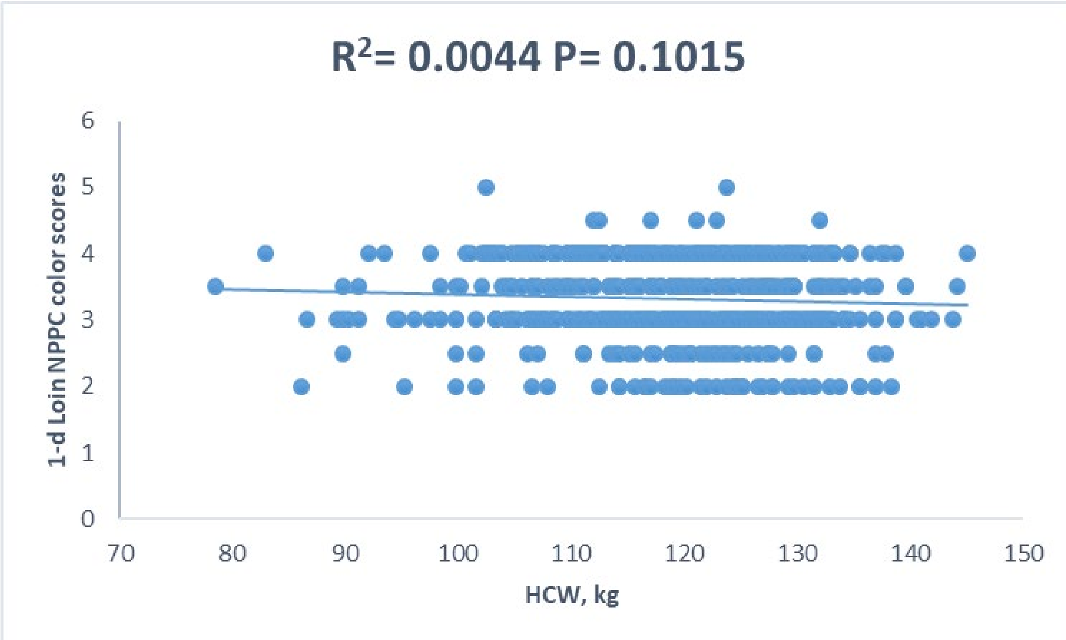
urface instrumental lightness (CIE L*). Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



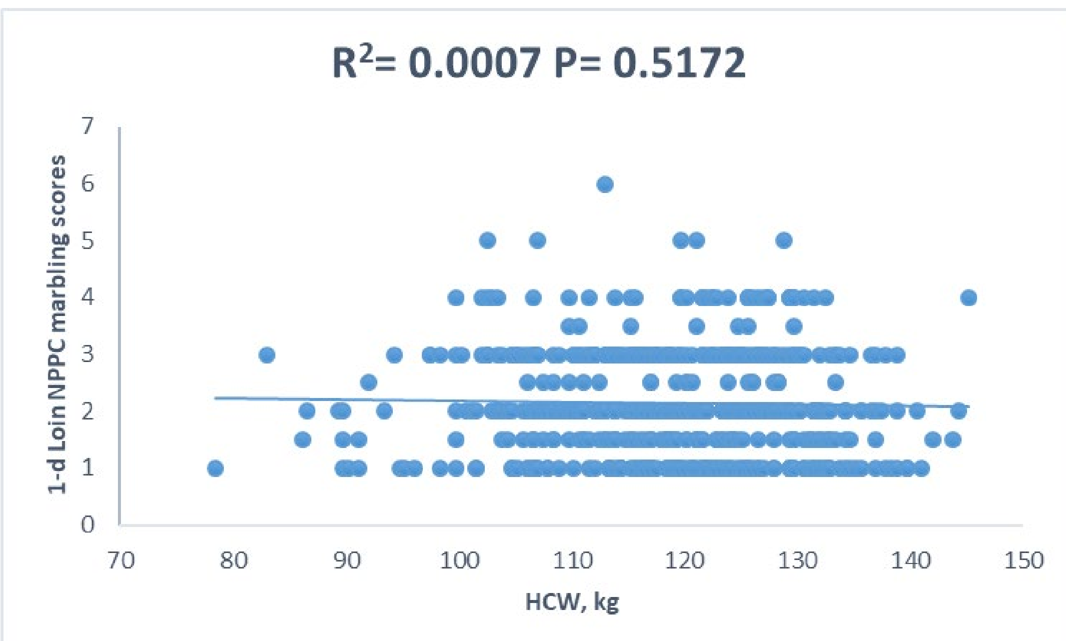
surface instrumental redness (CIE a*). Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



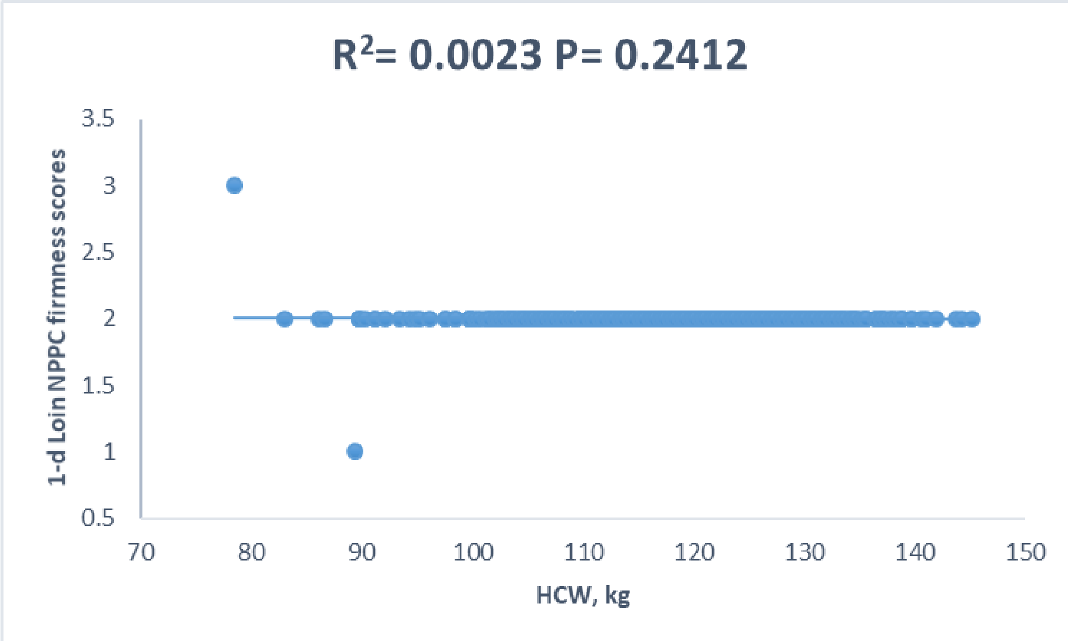
surface instrumental yellowness (CIE b*). Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).



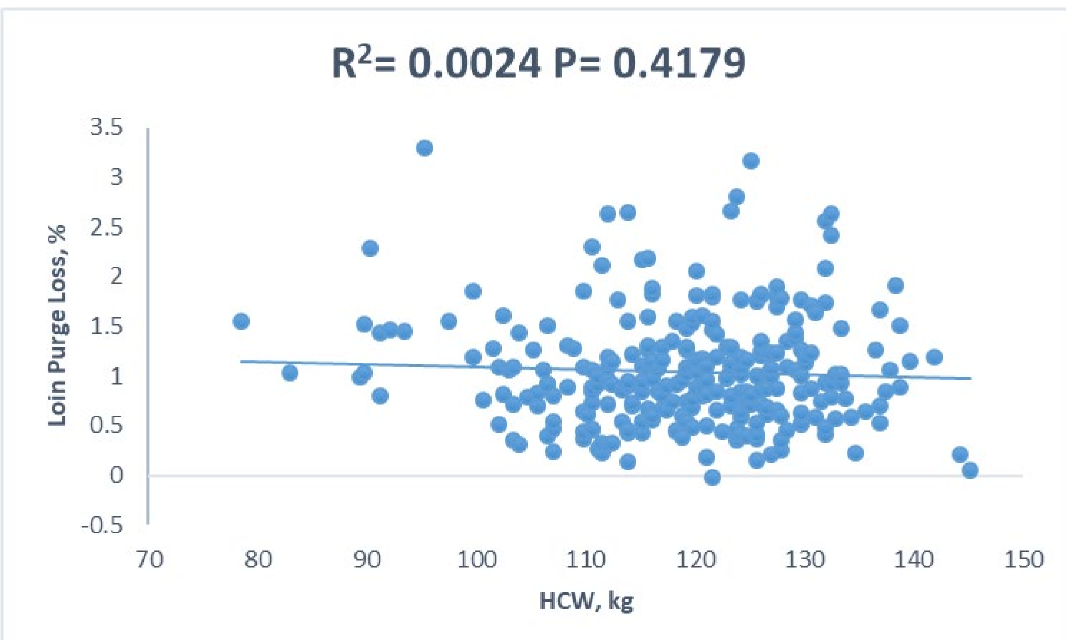
urface visual color. A greater number for visual color equates to a darker surface. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero (*P* > 0.05).



urface visual marbling. A greater number for visual marbling equates to greater extractable lipid estimates. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero (*P* > 0.05).



urface subjective firmness. A greater number for firmness equates to a more firm texture. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero (*P* > 0.05).



ging period. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero (*P* > 0.05).

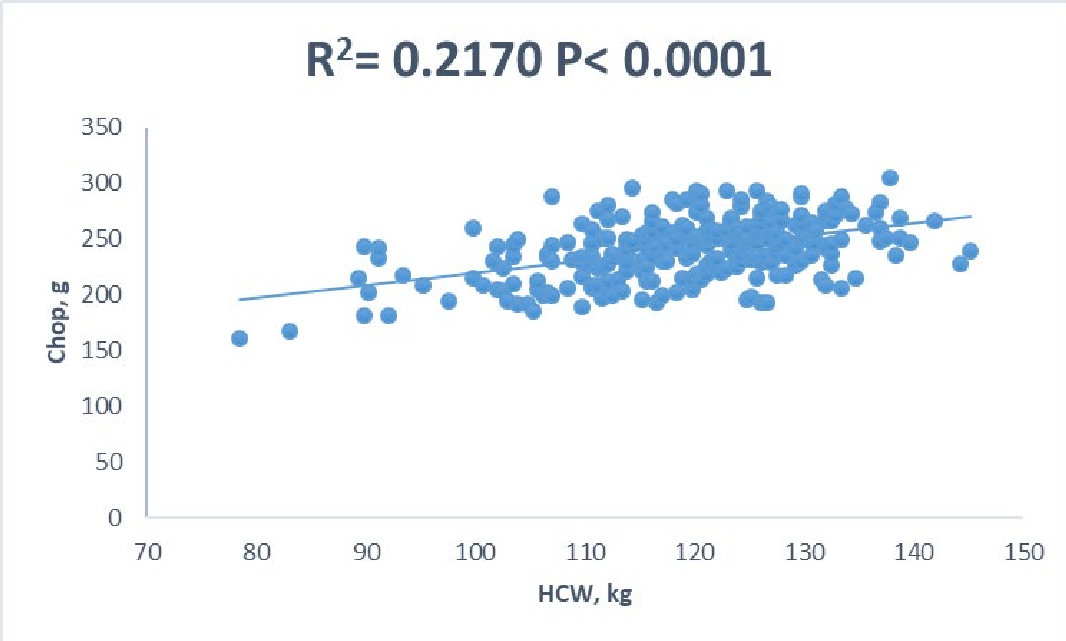


Figure 35. Effect of carcass weight (HCW) on aged (14 d) boneless loin chop weight. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).

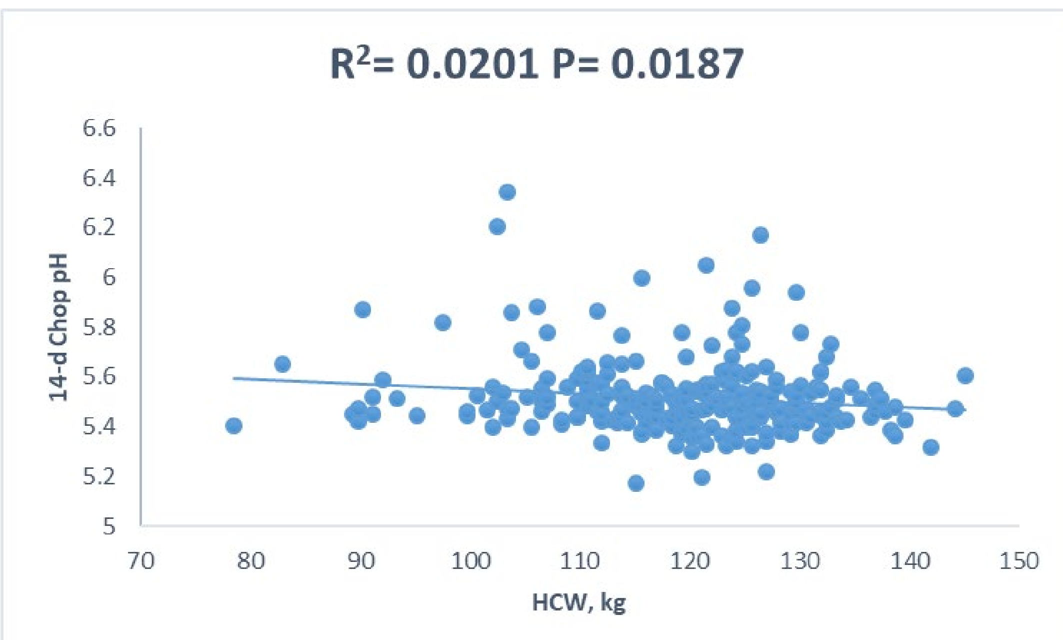


Figure 36. Effect of carcass weight (HCW) on aged (14 d) boneless loin chop ultimate pH. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).

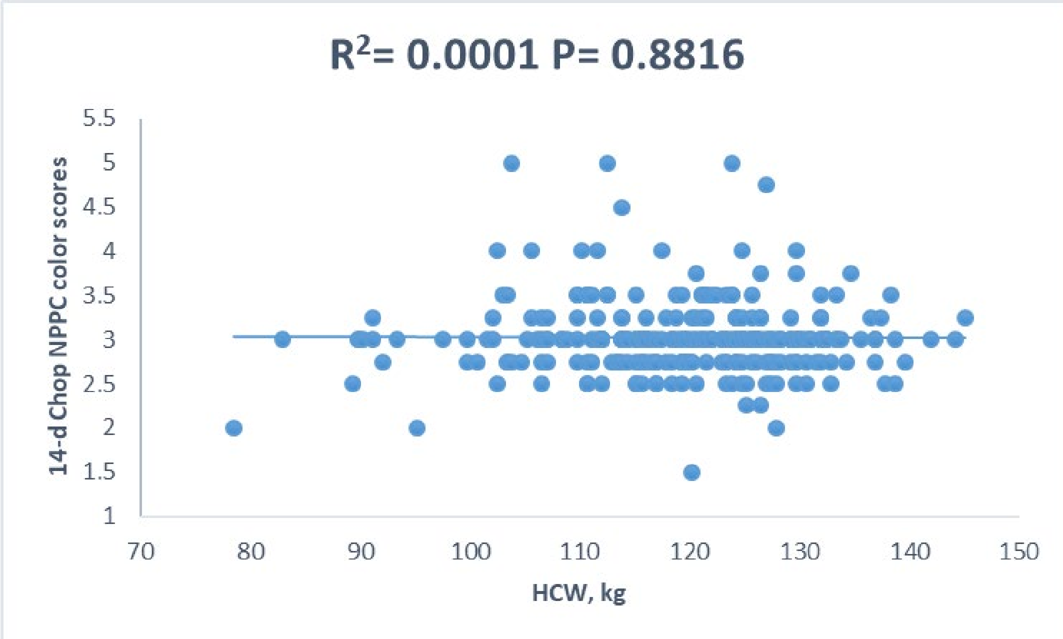


Figure 37. Effect of carcass weight (HCW) on aged (14 d) boneless loin chop visual color. A greater number for visual color equates to a darker surface. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).

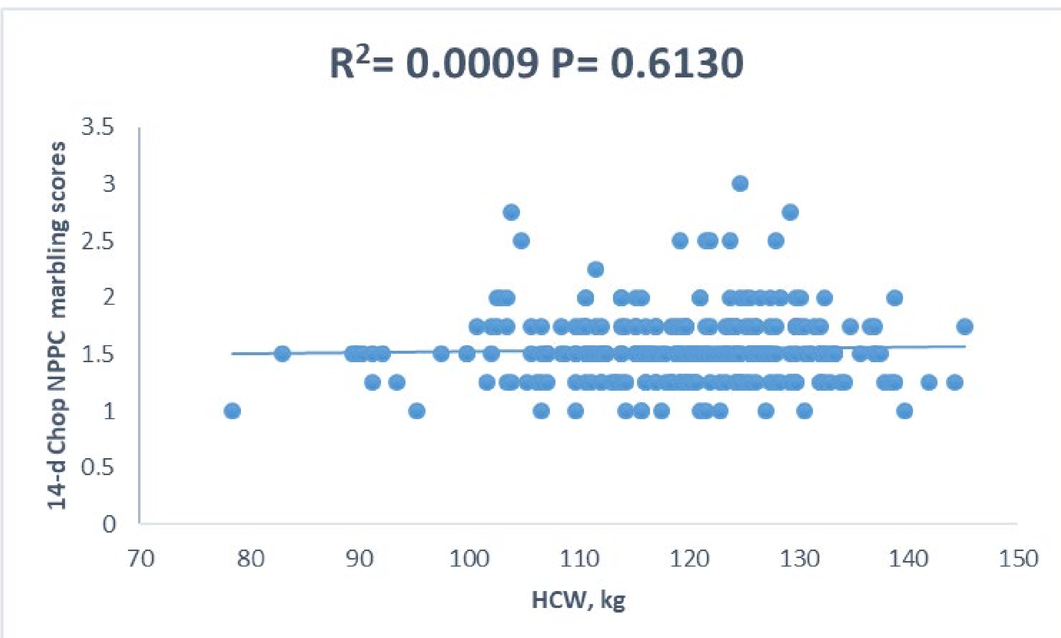


Figure 38. Effect of carcass weight (HCW) on aged (14 d) boneless loin chop visual marbling. A greater number for visual marbling equates to greater extractable lipid estimates. Data are depicted as the linear

regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).

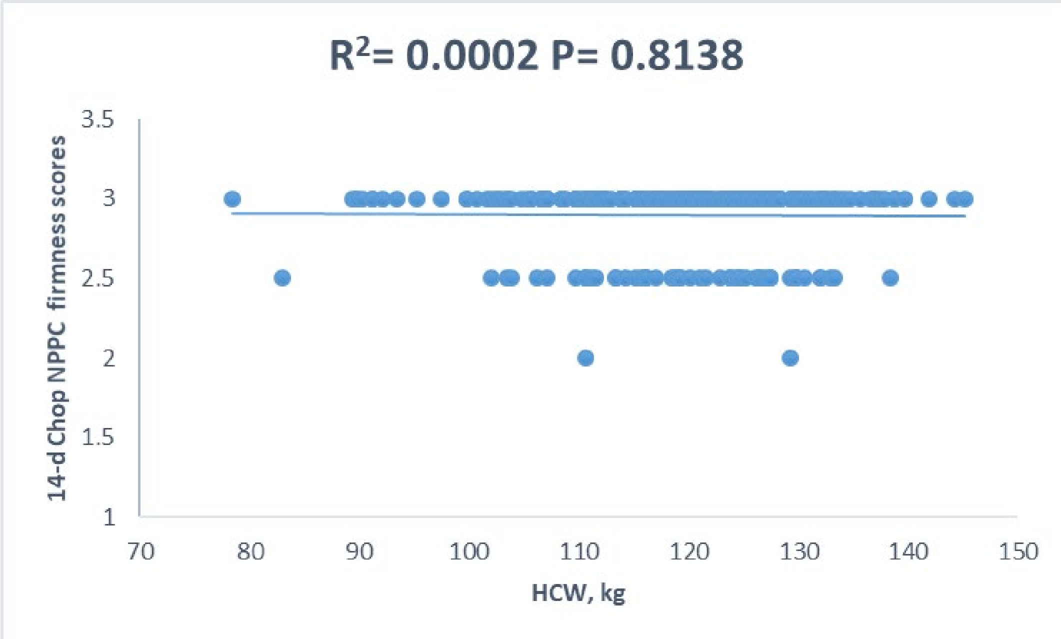


Figure 39. Effect of carcass weight (HCW) on aged (14 d) boneless loin chop subjective firmness. A greater number for subjective firmness equates to a more firm texture. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).

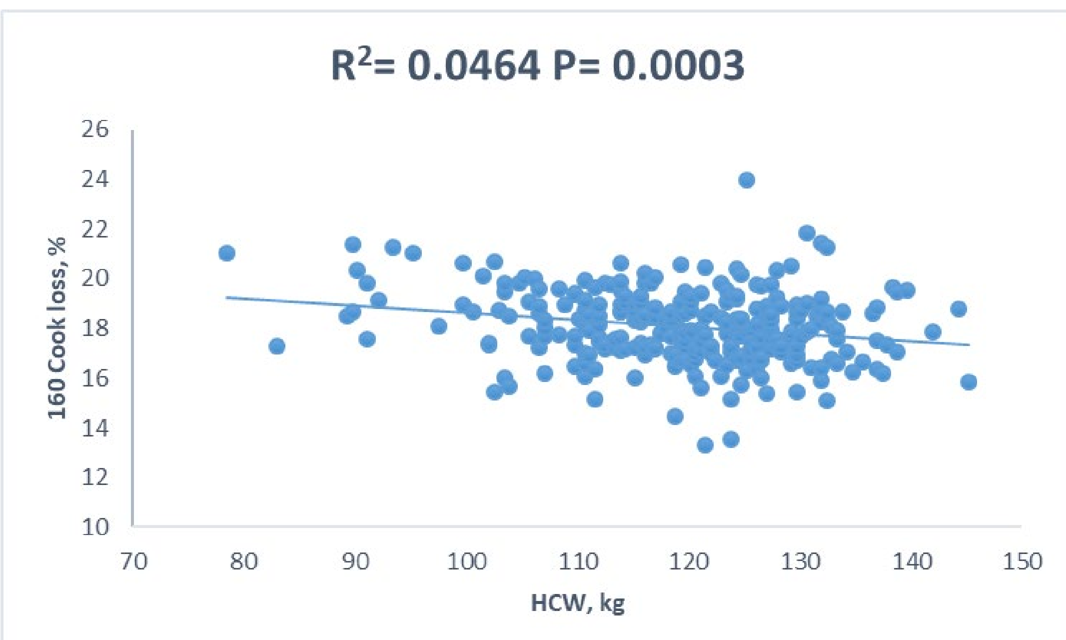


Figure 40. Effect of carcass weight (HCW) on cook loss of boneless loin chops cooked to an internal temperature of 160°F. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).

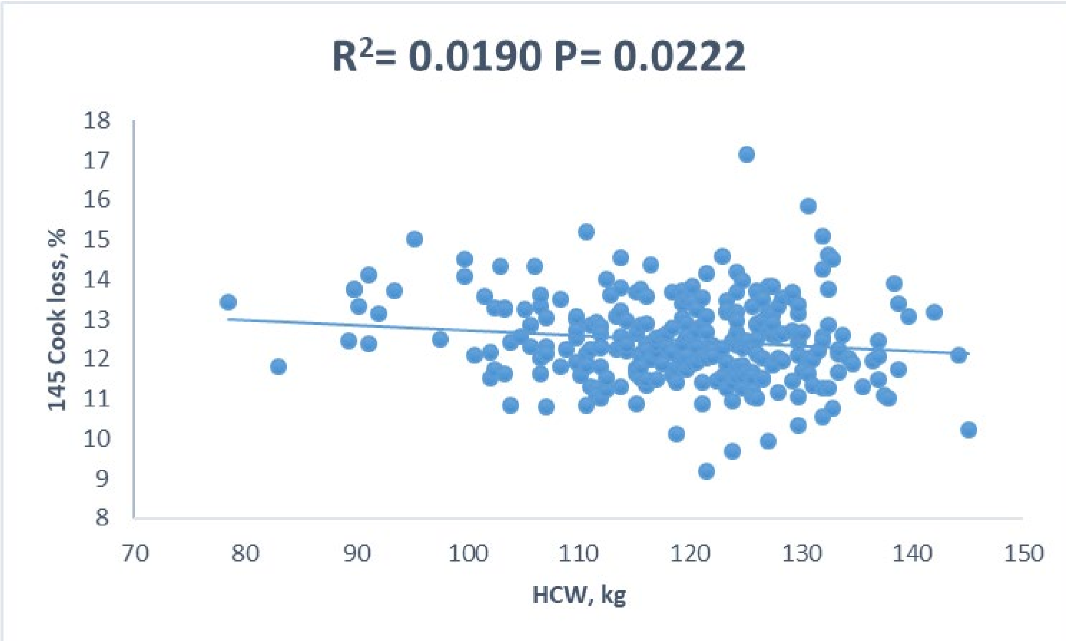


Figure 41. Effect of carcass weight (HCW) on cook loss of boneless loin chops cooked to an internal temperature of 145°F. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination included on figures where the slope of linear regression lines were different from zero ($P < 0.05$).

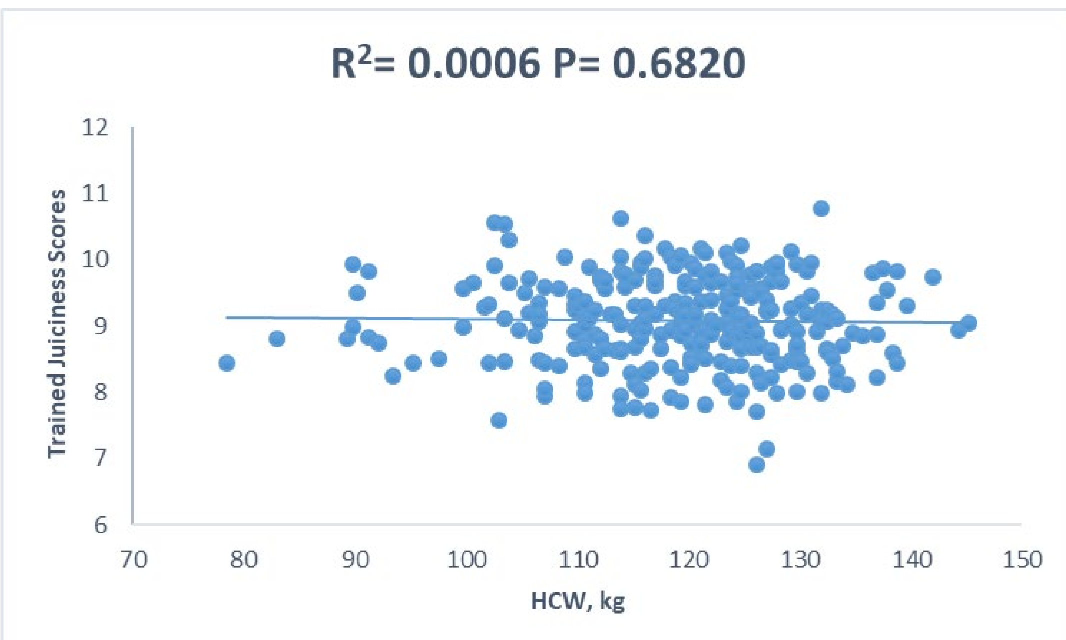


Figure 42. Effect of carcass weight (HCW) on sensory juiciness scores of boneless pork chops cooked to an internal temperature of 145°F. Data are depicted as the linear regression of the trait using carcass

weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).

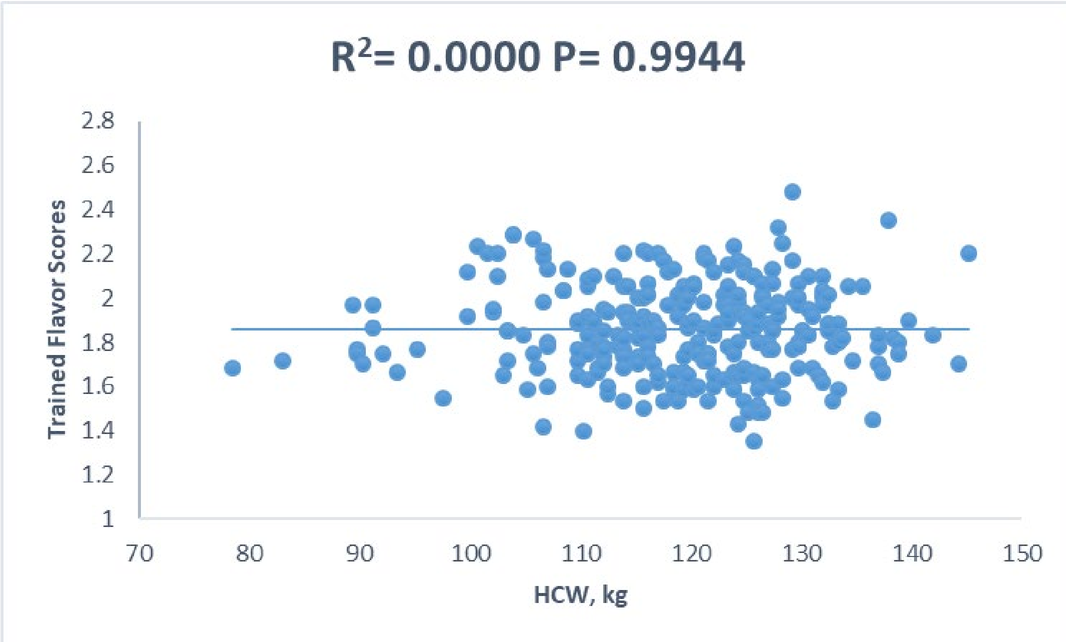


Figure 43. Effect of carcass weight (HCW) on sensory flavor scores of boneless pork chops cooked to an internal temperature of 145°F. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).

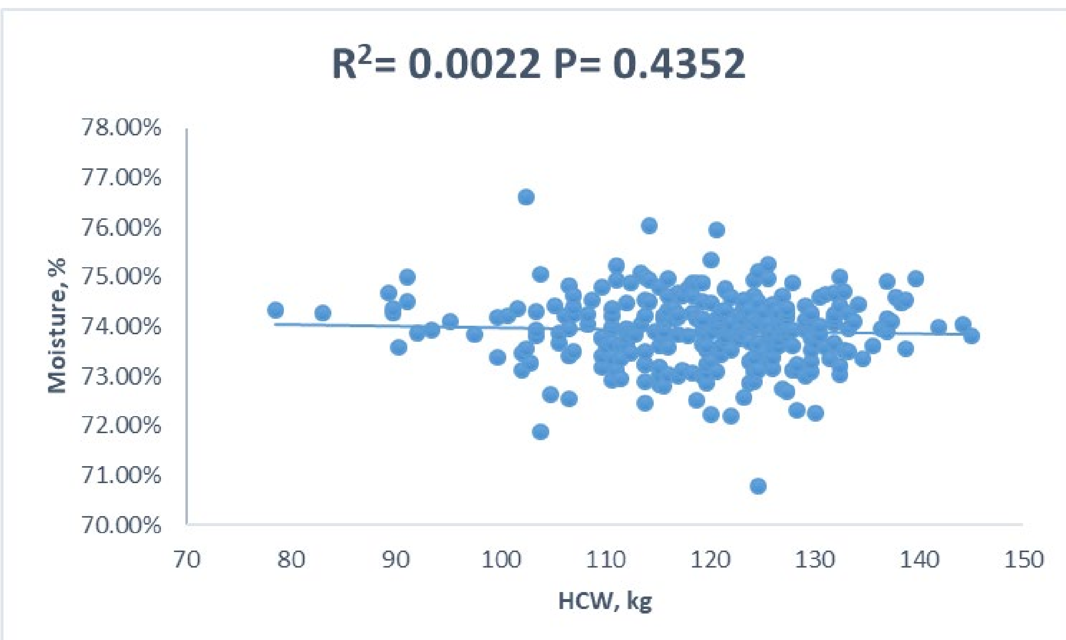


Figure 44. Effect of carcass weight (HCW) on moisture of boneless pork chops. Data are depicted as the linear regression of the trait using carcass weight as the independent variable. Coefficients of determination and probability values are included on figures even where the slope of linear regression lines may not differ from zero ($P > 0.05$).