

2018

The Effect of Increased Pork Hot Carcass Weights on Consumer Palatability Ratings of Top Loin Chops

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Recommended Citation

Rice, E. A.; Lerner, A. B.; Price, H. E.; Woodworth, J. C.; Tokach, M. D.; Dritz, S. S.; Goodband, R. D.; DeRouchey, J. M.; Allerson, M. W.; Gonzales, J. M.; and O'Quinn, T. G. (2018) "The Effect of Increased Pork Hot Carcass Weights on Consumer Palatability Ratings of Top Loin Chops," *Kansas Agricultural Experiment Station Research Reports*: Vol. 4: Iss. 9. <https://doi.org/10.4148/2378-5977.7689>

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Cover Page Footnote

Appreciation is expressed to the National Pork Board for funding and to Holden Farms, Inc. (Northfield, MN) for providing the animals, research facilities, and technical support. This project was completed in coordination with the University of Illinois, PIC North America (Hendersonville, TN), and the USDA Meat Animal Research Center (Clay Center, NE).

Authors

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The Effect of Increased Pork Hot Carcass Weights on Consumer Palatability Ratings of Top Loin Chops¹

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Summary

The objective of this study was to evaluate the effects of pork hot carcass weight on consumer palatability ratings of top loin chops. 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 taken 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, subjective color, subjective 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. Weight did not contribute ($P > 0.05$) to consumer quality ratings. These results indicate top loin chops from heavier weight carcasses have improved tenderness compared to chops from lighter carcasses.

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Introduction

The average hot carcass weight of pork carcasses in the United States has increased from 109 lb in 1995 to 210 lb in 2017.⁵ Increases in market weight are driven by increased packer efficiency and genetic improvement. With a projected increase of 1.3 lb per year, hot carcass weights may reach 260 lb by 2052.

In order for consumers to have a satisfactory eating experience, their expectations for tenderness, juiciness, and flavor must be met.⁶ Tenderness has been determined to be the most crucial factor in pork palatability.⁷ 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.^{8,9,10,11} Still, many of these studies have used weight ranges lower 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.¹² 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.¹³ Therefore, the objective of this study was to determine if increased hot carcass weights affect consumer palatability ratings of tenderness, juiciness, and flavor.

Procedures

The Kansas State University Institutional Animal Care and Use Committee and Institutional Review Board approved the protocols used in this experiment. Pork used in

⁵USDA. 2018. Hogs: Federally Inspected Slaughter Average Dressed Weight by Month and Year, US https://www.nass.usda.gov/Charts_and_Maps/Livestock_Slaughter/hgdrwgx8.php Accessed 6 June, 2018.

⁶O'Quinn, T. G., J. F. Legako, J. C. Brooks, and M. F. Miller. 2018. Evaluation of the contribution of tenderness, juiciness, and flavor to the overall consumer beef eating experience. *Transl. Anim. Sci.* 2:26-36. doi:10.1093/tas/txx008

⁷Wood, J. D., G. R. Nute, R. I. Richardson, F. M. Whittington, O. Southwood, G. Plastow, R. Mansbridge, N. da Costa, and K. C. Chang. 2004. Effects of breed, diet and muscle on fat deposition and eating quality in pigs. *Meat Sci.* 67:651-667. doi:<https://doi.org/10.1016/j.meatsci.2004.01.007>

⁸Cisneros, F., M. Ellis, F. K. McKeith, J. McCaw, and R. L. Fernando. 1996. Influence of slaughter weight on growth and carcass characteristics, commercial cutting and curing yields, and meat quality of barrows and gilts from two genotypes. *J. Anim. Sci.* 74:925-933. doi:10.2527/1996.745925x

⁹Beattie, V. E., R. N. Weatherup, B. W. Moss, and N. Walker. 1999. The effect of increasing carcass weight of finishing boars and gilts on joint composition and meat quality. *Meat Sci.* 52:205-211. doi:[https://doi.org/10.1016/S0309-1740\(98\)00169-7](https://doi.org/10.1016/S0309-1740(98)00169-7)

¹⁰Virgili, R., M. Degni, C. Schivazappa, V. Faeti, E. Poletti, G. Marchetto, M. T. Pacchioli, and A. Mordenti. 2003. Effect of age at slaughter on carcass traits and meat quality of Italian heavy pigs. *J. Anim. Sci.* 81:2448-2456. doi:10.2527/2003.81102448x

¹¹Harsh, B. N., E. K. Arkfeld, D. A. Mohrhauser, D. A. King, T. L. Wheeler, A. C. Dilger, S. D. Shackelford, and D. D. Boler. 2017. Effect of hot carcass weight on loin, ham, and belly quality from pigs sourced from a commercial processing facility

¹²Maltin, C. A., C. C. Warkup, K. R. Matthews, C. M. Grant, A. D. Porter, and M. I. Delday. 1997. Pig muscle fibre characteristics as a source of variation in eating quality. *Meat Sci.* 47:237-248.

¹³Wu, F., K. R. Vierck, J. M. DeRouchey, T. G. O'Quinn, M. D. Tokach, R. D. Goodband, S. S. Dritz, and J. C. Woodworth. 2017. A review of heavy weight market pigs: status of knowledge and future needs assessment. *Transl. Anim. Sci.* 1:1-15. doi:10.2527/tas2016.0004

this study was collected from pigs from a study in which they were intentionally fed to reach heavy live weights that exceed industry standards. Harvest of these animals took place at a commercial harvest facility on 2 separate days over a 4-d period. At harvest, carcasses were grouped by hot carcass weight into a light group (less than 246.5 lb; LT), medium-light group (246.5 to 262.5 lb; MLT), medium-heavy group (262.5 to 276.5 lb; MHVY), and heavy group (276.5 lb and greater; HVY). Whole boneless pork loins ($n = 200$, Institutional Meat Purchase Specification #413; North American Meat Processors Association, 2014) from the 4 separate weight treatments were collected ($n = 100/d$; $n = 25/\text{treatment}/d$) and transported back to Kansas State University Meat Laboratory (Manhattan, KS). 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 to bloom before instrumental color readings were taken on the ventral side of the loin using a Hunter Lab Miniscan spectrophotometer (Illuminant A, 2.54-cm 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.¹⁴ 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.

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 ThermoWorks 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

¹⁴National Pork Producers Council (NPPC). 1999. Official color and marbling standards. NPPC, Des Moines, IA.

quality level of each sample as either unsatisfactory quality, everyday quality, better than everyday quality, or premium quality.

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 and Discussion

Pork top loin chop color and marbling is important as it corresponds with product functionality and palatability.¹⁵ Additionally, some studies show that consumers make pork purchasing decisions based on color.¹⁶ In this study, weight treatments did not affect ($P > 0.05$) purge loss percentage, L* (lightness; 0 = black and 100 = white), a* (redness; -60 = green and 60 = red), b* (yellowness; -60 blue and 60 = yellow), subjective color scores, subjective marbling scores, or pH (Table 1). Thus, increased hot carcass weight did not affect the color and marbling traits of the loins.

The most important factors that affect a consumer's eating experience are tenderness, juiciness, and flavor. If one of these traits fail, there is a greater chance the product will not meet that consumer's expectations.³ There were no ($P > 0.05$) weight class effects for consumer juiciness, flavor, and overall like ratings (Table 2). Weight did affect ($P < 0.05$) consumer tenderness ratings, where chops from the LT weight group had lower ($P < 0.05$) ratings for tenderness (tougher) than all other weight groups, which were not different ($P > 0.05$) from each other. Other studies have reported similar data with chops from heavier carcasses being more tender.^{17,18} This could be due to the current industry chilling practices in which carcasses are chilled as quickly as possible to prevent pale, soft, and exudative (PSE) meat quality defects. Compared to the larger, heavier carcasses which cool slower, smaller carcasses chill at a faster rate. This increased chilling of smaller carcasses can result in cold shortening that can ultimately lead to a tougher and less desirable product.¹⁹ This difference in chilling rate among weight groups in this study likely contributed to the observed differences in tenderness observed in this study. Additionally, consumers also rated a greater ($P < 0.05$) percentage of samples from the HVY weight group as acceptable for juiciness, compared to all lighter carcass weight groups. There were no differences ($P > 0.05$) observed

¹⁵Norman, J. L., E. P. Berg, H. Heymann, and C. L. Lorenzen. 2003. Pork loin color relative to sensory and instrumental tenderness and consumer acceptance. *Meat Sci.* 65:927-933. doi:[https://doi.org/10.1016/S0309-1740\(02\)00310-8](https://doi.org/10.1016/S0309-1740(02)00310-8)

¹⁶Brewer, M. S., L. G. Zhu, and F. K. McKeith. 2001. Marbling effects on quality characteristics of pork loin chops: consumer purchase intent, visual and sensory characteristics. *Meat Sci.* 59:153-163. doi:[10.1016/S0309-1740\(01\)00065-1](https://doi.org/10.1016/S0309-1740(01)00065-1)

¹⁷Durkin, I., M. Dadic, D. Brkic, B. Lukic, G. Kusec, M. Mikolin, and I. Jerkovic. 2012. Influence of gender and slaughter weight on meat quality traits of heavy pigs. *Acta Agric. Slov.* 3:211-214. *J. Anim. Sci.* 95:4958-4970. doi:[10.2527/jas2017.1674](https://doi.org/10.2527/jas2017.1674)

¹⁸Bertol, T. M., E. A. Oliveira, A. Coldebella, V. L. Kowski, A. J. Scandolera, and M. B. Warpechowski. 2015. Yield of pigs slaughtered over 100 kg live weight. *Arq Bras Med Vet Zootec.* 1166-1174. doi:[dx.doi.org/10.1592/1678-4162-8113](https://doi.org/10.1592/1678-4162-8113)

¹⁹Dransfield, E., and D. K. Lockyer. 1985. Cold-shortening toughness in excised pork M. Longissimus dorsi. *Meat Sci.* 13:19-32. doi:[https://doi.org/10.1016/S0309-1740\(85\)80002-4](https://doi.org/10.1016/S0309-1740(85)80002-4)

among weight groups for the percentage of samples rated acceptable for both flavor and overall like. Following this trend, consumers perceived a lesser ($P < 0.05$; Table 3) percentage of chops from HVY weight carcasses as unsatisfactory quality in comparison LT and MLT weight groups. Chops from MHVY carcasses were similar ($P > 0.05$) to all weight treatments. There were no differences ($P > 0.05$) among any of the weight groups for percentage of chops consumers perceived as everyday quality, better than everyday quality, and premium quality.

In conclusion, this study shows that as hot carcass weights increase, there are no negative effects on loin quality and palatability characteristics. Moreover, tenderness was positively affected by increased weight; increasing the likelihood a consumer will have a satisfactory eating experience and thus encouraging repeat purchases.

Table 1. 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 ⁵	0.13	0.16	0.33	0.18	0.16	0.10	0.08	0.01
<i>P</i> -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).

¹LT = 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.

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

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

⁴a* (redness; -60 = green and 60 = red).

⁵b* (yellowness; -60 blue and 60 = yellow).

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

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

Table 2. Least squares means for consumer (*n* = 197) palatability ratings¹ 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
<i>P</i> -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).

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

²LT = 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.

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

Table 3. 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 ($P < 0.05$).

¹Carcass 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.

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

Table 4. Least squares means for consumer ($n = 197$) ratings of pork top loin chops of varying hot carcass weight groups for perceived quality¹

Carcass weight ²	Unsatisfactory	Everyday quality	Better than everyday	Premium
LT	17.3 ^a	48.7	25.6	7.6
MLT	14.1 ^a	48.3	26.6	10.1
MHVY	16.3 ^{ab}	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 ($P < 0.05$).

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

²Carcass 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.

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