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EFFECTS OF SEASONAL ENVIRONMENT, ON-FARM HANDLING, TRANSPORT STOCKING DENSITY, AND TIME IN LAIRAGE ON CORE BODY TEMPERATURE AND PORK LEAN QUALITY OF MARKET WEIGHT PIGS

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Introduction

The U.S. pork industry has become increasingly concerned with pork lean quality and its possible effects on both domestic and foreign pork demand (NPB, 2003). Muscle metabolism ante-mortem and early post-mortem has a direct impact upon ultimate pork quality endpoints (Briskey, 1964). Pre-harvest stress has a direct association with muscle metabolism (Gregory, 1998). Evaluating ante-mortem body temperature along with lean quality parameters would help to answer more questions in reference to pre-harvest stress as it associates with non-conforming lean quality.

Core body temperature serves as an indirect indicator of metabolic rate (Webb, 1995). During pre-harvest stress, pigs are often near their upper threshold of thermal tolerance (Lambooij and van Putten, 1993). The temperatures within the digestive tract of live animals should produce values representative of core body temperature

Numerous research initiatives have been conducted to quantify the relationship between ante-mortem stress, animal welfare, and lean quality of market hogs. However, no known study has utilized a non-invasive, objective assessment of transport stress on a large-scale as an indicator of animal well-being and lean quality parameters.

Objectives

The present series of studies were conducted to evaluate two seasonal environments (temperate and cold stress), two on-farm handling intensities (normal and passive), two transport stocking densities (tight and loose) and two lairage lengths (45-min and 3-h) on digestive tract temperature and pork lean quality.

Methodology

Sensor Ingestion

Market hogs at an average live weight of 125 kg were harvested at two representative environmental situations: temperate (TMP) 15-25˚C, < 50% RH (n = 111) and cold stress (CS) < 0˚C (n = 113). Approximately 16-h prior to harvest, all test animals were withheld from conventional feeding. Approximately 1-h later, all animals were individually snared by a conventional hog snare, then ear tagged for treatment identification and tattooed for carcass identification. At the same time, a computer-activated temperature logging device marketed as an Ibutton (Dallas Semiconductor Corp. Dallas, TX www.ibutton.com) was placed within a conventional small balling gun, placed within the animal's mouth, and the plunger was depressed. Following Ibutton ingestion, animals were allowed to rest prior to transport to the abattoir. The Ibuttons were calibrated to log temperature at 10min intervals.

Handling During Loading

Loading for transport initiated at 0400-h. Half of all test animals (n = 56) were randomly subjected to passive handling and the other half conventional (n = 56) handling. Each group was loaded on individual trucks with identical trailer dimensions. The passively handled pigs were loaded first with that trailer waiting at the loadout facility for the conventionally handled pigs to be loaded. The passively handled pigs (PAS) were moved at a moderate to slow handling speed, with little to no handler vocalization, and limited utilization of paddles or boards, and absolutely no electric prod usage. The conventionally handled pigs (CON) were subjected to a more rapid-paced handling, extensive vocalization by handlers, and extensive physical manipulation via hog paddles and boards, as well as selective utilization of electric prods. The CON handling treatment is indicative of typical, welfare-conscious on-farm handling. Ear tags were recorded for treatment identification.

Loading Density

As each respective handling group was loaded, a portion of the pigs (approximately half) were allotted to a tight loading density (T) within the trailer (0.4 m^2 per animal). The other portion of the test group was subjected to a looser, more restful density, (L) allowing all animals to lie down (0.5 m^2 per animal). Loading density specifications were modified from Lambooij and van Putten (1993). Both trailers were loaded with the same proportions and location within the trailer for each stocking density. In accordance to trailer dimensions, non-test animals (n = 4) were added to each trailer to insure proper stocking densities. At the conclusion of loading, both trailers contained 60 market hogs with 56 from each trailer being test animals. Ear tags were recorded for treatment identification.

Unloading and Lairage

Following a 2.5-h trip to a commercial pork processing facility (Tyson Foods, Columbus Junction, IA), the passively handled animals (the first trailer loaded) were unloaded immediately upon arrival. Half of the test animals within each trailer (n = 56) were randomly allocated to one of two lairage treatments, 45-min (45M) or 3-h (3H). Animals were given free access to water during lairage. Ear tags were recorded for treatment identification. All animals were subjected to handling by the researchers during unloading and by the plant personnel for the walk to the stunning chute. All animals were subjected to humane head-to-heart electrical stunning procedures.

Post-Mortem Measurements

Following humane harvest and evisceration, the eviscera was inspected for retrieval of the Ibuttons. A stud finder with a metal scan setting (Zircon Corp., Campbell, CA) was utilized to expedite object retrieval. Ibuttons (n = 172 of 224) were recovered for downloading of temperature data onto a personal computer after returning to the University of Missouri.

Carcass Composition and Quality Assessment

All carcass parameters were assessed from the right carcass side. At the harvest floor grading station, hot carcass weight was recorded. Additionally, the Carcass Value Technology (CVT) system (Animal Ultrasound Services, Ithaca, NY) was used to evaluate average fat depth and loin muscle depth for the calculation of percent muscle. Intramuscular pH and temperature was assessed approximately 1-h post-mortem within the longissimus muscle (LM) between the 10^{th} and 11^{th} ribs utilizing a portable pH meter (pH Star, SFK Co., Peosta, IA) and temperature probe (Koch Equipment Co., Kansas City, MO). At fabrication, all right side skinned loins (IMPS 410; NAMP, 1997) were collected, weighed, and subsequently shipped to the University of Missouri Meat Laboratory.

Pork Quality Assessment

Further fabrication was initiated at approximately 30-h postmortem. The loin was divided between the 10^{th} and 11^{th} ribs and after allowing a 15-min oxygenation period, ultimate muscle pH and objective lean color analysis (L*, a*, b*) was conducted using a Hunter MiniScan SE with an illuminant setting of D65/10. Following deboning and sirloin removal, one 2.54 cm LM chop was fabricated, originating from the initial $10^{th}/11^{th}$ rib separation. A 2.54 x 2.54 cm section was further fabricated from the center of the lean tissue of the chop for drip loss analysis. The loin section generated from the loin section posterior to and including the 11^{th} rib was weighed, then vacuum packaged and stored for 7d at 4^{o}C for subsequent assessment of purge loss.

Statistical Analysis

All assessments of lean quality, digestive tract temperature, and carcass data were analyzed using ordinary least squares (PROC GLM, SAS Inst., Inc., Cary, NC). Seasonal environment (harvest date), on-farm handling intensity, stocking density, and lairage time were utilized as a fixed effect. Ibutton temperatures from individual animals were averaged for three time periods representing loading (0400-h – 0530-h) transport (0531-h – 0800-h) and lairage (0801-h – 1-h following harvest of the last animal). These averages were evaluated as repeated measures within a split plot in time. Mean separation was accomplished using the P-DIFF option of SAS at an Alpha level of 0.05.

Results & Discussion

Carcass Composition

Market hogs from the TMP harvest group had heavier hot carcass weights, and greater loin muscle depths ($P < 0.0001$) than market hogs from the CS harvest group (data not provided). However, market hogs in the TMP group also had greater average fat depth ($P < 0.01$) than animals in the CS group; therefore no difference ($P > 0.05$) was found between harvest groups for calculated percent muscle. This suggests that between animal harvest groups, metabolic rate as it associates with lean mass should be similar.

Pork Quality

Market hogs from the TMP harvest group had higher 1-h pH values ($P < 0.0001$) within the LM and tended to have higher ultimate pH values ($P = 0.07$) than hogs from the CS harvest group (Table 1). Conventionally (CON) handled market hogs loaded at a loose (L) stocking density displayed darker, more desirable L* values ($P < 0.05$) than PAS handled hogs loaded at the same stocking density (Table 1). This suggests that the time efficiency of CON handling could actually be less stressful than the more time consuming PAS handling of market hogs. Market hogs from the TMP harvest had lower drip loss percentages ($P < 0.0001$) than market hogs from the CS harvest (Table 1). This could be attributed to the higher 1-h pH values reported during TMP weather. This higher pH early postmortem could possibly impede protein denaturation of the musculature, hence improving water holding capacity. Additionally, market hogs loaded at a L stocking density had lower drip loss percentages ($P < 0.05$) than those loaded at a T stocking density (Table 1). This could be attributed to an endocrine stress response increasing the muscle metabolism of the more tightly stocked animals.

Digestive Tract Temperature

Animals from both harvest groups, cold stress and temperate, displayed lower digestive tract temperatures during lairage than during loading and transport ($P < 0.05$), suggesting that the more extended lairage treatment could allow metabolic rate to slow prior to harvest, possibly leading to improved lean quality.

Conclusions

Further analysis and investigation should be conducted to further develop the relationships between on-farm handling intensity, stocking density on the truck, and lairage time. However, it appears the extra time associated with passively loading market hogs could actually be more stressful than handling them at a conventional rapid pace. Assessment of digestive tract temperature holds promise as an indicator of metabolic rate. Further analysis is needed to assess how digestive tract temperature correlates with lean quality parameters.

Tables and Figures

Table 1. Effect of seasonal environment, on-farm handling intensities, transport stocking density and lairage length on loin muscle quality characteristics

	Harvest Group[a] (HG)		Handling Intensity[b] (HI)		Stocking Density[c] (SD)		Lairage Time[d] (LT)		Level of Significance[e]					
Characteristic	TEM	CS	PAS	CON	L	T	3H	45M	HG	HI	SD	LT	HI X SD	SD X LT
1-h pH	6.24	5.99	6.11	6.13	6.12	6.12	6.10	6.14	***	NS	NS	NS	NS	NS
Ultimate pH Loose Tight	5.80	5.75	5.77 5.74[f] 5.79[f]	5.78 5.81[f] 5.74[f]	5.77	5.77	5.75	5.80	x	NS	NS	x	*	NS
Hunter L* Loose Tight	48.13	47.35	48.07 48.39[f] 47.74[fg]	47.41 46.81[g] 48.02[fg]	47.60	47.88	48.26	47.22	x	NS	NS	*	*	NS
Hunter a*	8.20	8.80	8.41	8.60	8.49	8.52	8.56	8.45	**	NS	NS	NS	NS	NS
Hunter b* 3-h 45-min	14.70	14.82	14.87	14.63	14.68 14.97[fg] 14.71[g]	14.83 15.27[f] 14.27[g]	15.05	14.47	NS	NS	NS	**	NS	*
Drip, %	3.22	6.74	4.84	4.71	5.10	4.46	4.87	4.70	***	NS	**	NS	NS	NS
Purge, %	2.62	2.27	2.33	2.55	2.60	2.30	2.55	2.35	x	NS	NS	NS	NS	NS

[a]Harvest Group: TEM= Temperate, CS= Cold Stress; respectively.
[b]Handling Intensity: PAS= Passive, CON= Conventional, respectively.
[c]Stocking Density: L= Loose, T= Tight, respectively.
[d]Lairage Time: 3H= 3 hours, 45M= 45 minutes, respectively.
[e]Level of significance: NS= not significant, x= $P < 0.10$, *= $P < 0.05$, **= $P < 0.01$, ***= $P < 0.0001$, respectively.
[f, g]Values lacking a common superscript within an interaction differ ($P < 0.05$).

Table 2. Relationships between harvest group and handling intensity with the average Ibutton temperature (^oC) within the digestive tract during loading, transport, and lairage

	Average Ibutton Temperature(^oC) During: Loading	Transport	Lairage
Handling Intensity			
Passive	39.76^a	39.47^b	39.10^c
Normal	39.64^a	39.54^b	39.21^c
Harvest Group			
Cold Stress	39.66^a	39.55^b	39.41^c
Temperate	39.74^a	39.45^{bc}	38.90^d

[a, b, c, d]Values lacking a common superscript within an interaction differ ($P < 0.05$).

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