Title: Comparison of chute design on the ease of loading finisher pigs. How does this affect their performance, welfare parameters and overall economics to the producer? **– NPB #06-062**

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Industry Summary:

Marketing and transportation stress not only costs the industry due to fatigued, injured and dead pigs, but has a direct impact on the quality of pork delivered to the consumer. The loading process in particular has been reported to be the most stressful part of the whole marketing process due to the pigs having to navigate tight corners, narrow incline, temperature and climate changes, and movement from light to dark areas. By understanding basic big biology (that they move from dark to light areas, they will move better with another pig, that they do better walking up inclines that are less steep) we designed a state of the art loading gantry system that was constructed of an aluminum covered chute and measured 91.4 cm in width, 3.1 m in height, and 9 m in overall length, including a 7.9 m sloped section and two dual pivoting extension systems that allowed for proper positioning to both the barn and trailer. A cushioned bumper dock system was incorporated into the loading gantry design to completely eliminate gaps from the barn to the loading gantry. The flooring material consisted of metal coated with epoxy (designed to mimic the feel of concrete on the pigs feet) and had an inverted stair step design with cleats 2.5 cm in height and spaced 20.3 cm apart. The gantry slope was approximately 7 degrees to the bottom deck and 18 degrees to the upper deck of the trailer. The state of the art loading gantry system utilized an industrial rope lighting system designed to provide a soft, continuous light source that minimized shadowing. This state of the art loading gantry system was compared back to a traditional metal covered chute. This chute was 76.2 cm in width, 2.3 m in height, and 4.6 m in length, and used square stock (2.5 cm) metal cleats which were spaced 20.3 cm apart. The traditional chute included a flat pivot section on each end to accommodate the angle that the trailers were positioned relative to the finishing facility. The slope of the chute used to load the pigs onto the trailer was approximately 19 degrees to the bottom deck. The trailer included an internal ramp raised 23 degrees for access to the upper deck. One incandescent lamp fixture (60 watts) was placed at the entrance to the traditional chute.

Pigs loaded using the state of the art loading gantry system experienced fewer electric prods, slips, falls, vocalizations, and pile ups. The state of the art loading gantry system lowered total losses (total crippled + total stressed + total dead) in first pull pigs. The state of the art loading gantry system influenced several pork quality attributes. Loins taken from pigs from the first pull loaded with the state of the art loading gantry system had higher initial and 24 h pH and tended to have higher Japanese Color Score cut values, but lower loin L* values. The higher JCS cut values and lower L* values indicate a darker, redder color meat. Among loins collected from pigs loaded with the state of the art loading gantry system that came from the close out pull loins had higher 24 h pH and JCS rib values, but lower L* values. This investigation has provided data to support changes in loading system design that may ultimately lead to the improvement of performance, welfare, and pork quality.

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Scientific Abstract:

Handling and transport losses can encompass several challenges experienced frequently by producers and packers alike. Marketing and transportation stress not only costs the industry due to mortalities, but has direct impact on the quality of pork delivered to the consumer (Barton-Gade, 1992; Geverink et al., 1996; Hambrecht, 2005). The objectives of the current study was to determine if loading system affects welfare parameters for the finisher pig at the time of marketing, incidence of transport losses during transportation or at the packing plant, and pork quality attributes. Two loading systems (prototype loading gantry [P] vs. traditional chute [T]) were compared on the first pigs marketed from a finishing facility (first pull [FP] pigs) and on the last pigs marketed from a finishing facility (closeout [CO] pigs). ***Experiment One:*** Loading system influenced welfare parameters ($P < 0.01$) of both FP and CO pigs at the time of marketing. Pigs loaded on the P chute experienced fewer electric prods, slips, falls, vocalizations, and pile ups, regardless of time of marketing. ***Experiment Two:*** Loading system influenced total losses ($P < 0.03$) in FP pigs. Pigs loaded on the P chute during the FP had fewer total losses. However, all other performance measures at the plant between pulls and loading system design were not different ($P > 0.05$). ***Experiment Three:*** Loading system did influence several meat quality attributes evaluated. In a comparison of FP pigs, loins from pigs loaded with the P loading system had higher ($P < 0.05$) initial and 24 h pH and tended to have higher ($P = 0.08$) JCS cut values, but lower ($P = 0.03$) loin L* values. The higher JSC cut values and lower L* values indicate a darker, redder color meat. Among CO pigs, loins from pigs loaded with the P loading system had higher ($P = 0.01$) 24 h pH and JCS rib values, but lower ($P = 0.06$) L* values. Understanding key factors influencing losses during this time frame enables targeted interventions to improve both welfare and meat quality. This investigation has provided data to support changes in loading system design that may ultimately lead to the improvement of performance, welfare, and pork quality.

IV. Introduction:

Animal transportation is a growing issue of concern in many countries around the world. The general public, livestock producers and research scientist have shown an increasing interest in assuring proper animal care and handling (von Borell and Schaffer, 2005). There is a corresponding increase in efforts by research and educational institutions, government agencies, enterprise managers, health care providers and others in developing and accessing information that assists in creating appropriate management procedures and humane conditions for the transportation of farm animals (von Borell and Schaffer, 2005).

Defining transport losses

Handling and transport losses can encompass several challenges experienced frequently by producers and packers alike. The term transport loss is used loosely, but most commonly references those pigs that die during transport (dead on arrival; DOA) and pigs that become non-ambulatory during the marketing process. Most recently, fatigued pigs were defined by scientists and industry representatives as “a non-ambulatory, non-injured pig that without obvious injury, trauma, or disease, refuses to walk at any stage of the marketing channel from loading at the farm to stunning at the plant” (Ritter et al., 2005). Anderson et al. (2002) defined a non-ambulatory pig as “a pig that cannot keep up with its contemporaries during loading, unloading, or moving through the packing plant.”

Incidence of transport losses and economical implications to the U.S. swine industry

Based on several field studies, the incidence of transport losses in market-weight pigs is approximately 1% (Ellis et al., 2003; Ellis and Ritter, 2006). The national average for the percentage of dead pigs at U.S. packing plants was low (~0.09%) from 1990-1993, but increased to 0.30% in 1998. In contrast to the increased prevalence of the problem experienced in the late 1990’s, it has been reported that the incidence of dead pigs at the plant has declined to 0.22% in 2004 (Ellis and Ritter, 2006). Additionally, the incidence of non-ambulatory (fatigued) pigs has been recently estimated in the range of 0.4% to 0.8% based on two large field studies conducted within two different production systems (Ellis et al., 2003; Rademacher and Davies, 2005). As the issue pertains to pork quality, problems with color have been estimated to cost $0.43 per head, for bruising, $0.08 per head and for pale, soft and exudative (PSE) meat, $0.90 per head (Stetzer and McKeith, 2003). This results in a total lost opportunity for the U.S. swine industry of $254,104,500 or $2.44 per finisher head per year. Belk et al., (2002) reported approximately 10% more pork would be suitable for high quality exports to Japan when pigs are handled quietly and usage of electric prods is reduced. Economic losses associated with pigs that die or become fatigued during transportation and at the packing plant, as well as the negative attributes associated with poor meat quality, have been estimated to cost the U.S. swine industry $300 to 350 million dollars annually (Ellis et al., 2003; Stetzer and McKeith, 2003). Economic losses associated with dead and fatigued pigs are not confined to mortalities and poor meat quality. We were unable to find any research to quantify the economic impact of poor handling and transportation on the farm and packing plant employee. However, over one-third of employee injuries within finishing operations are animal handling related, of which a majority are due to sorting and loadout procedures (Hill et al., 2007). Fatigued and dead pigs disrupt standard animal flow, resulting in reduced transportation and packing plant efficiencies. In many cases these animals require specialized handling practices to ensure their well-being and such practices result in additional use of personnel, time, and labor, thereby reducing unloading efficiency at the processing facility (Hill et al., 2007).

Possible stressors that market weight pigs are exposed to during the marketing process

A substantial trade involving the transportation of pigs occurs in the USA. Road transport is a complex operation made up of several components including exposure to a novel environment, loading, reduction in the space allowance, temperature extremes, vibration and jolting (Hails 1978; Grigor et al 1997). Loading has been cited as one of the most stressful aspects of the transport procedure for animals (Trunkfield & Broom 1990; Grandin 1997) because of the physical exertion required, the noise, and the effects of contact with people during handling. Mayes and Jesse (1980) reported that throughout the entire transportation process that the highest heart rate was collected when pigs climbed high and low loading chutes. In addition the authors reported that if the individual pigs' heart rate exceeded 220 – 240 beats per min^{-1} pigs would stop moving or lie down. Grandin (1993) hypothesizes that for pigs the difficulty in climbing loading chutes is mainly psychological. Pigs can be seen refusing to try and can turn their sides towards "steep" ramps. It seems that to these pigs which have no previous experience with such surroundings a loading ramp with an angle of 30^o does not look accessible. The Trucker Quality Assurance Program does provide details for adjustable (25^o) and non-adjustable (20^o) slopes respectively. However, chute design components (for example types of flooring, cleats [raised or inverted] and lighting levels) have not been studied on a production unit and pigs have not been "asked" if they will climb these chutes easily, without balking.

Gauntlet set forth by the National Pork Board

In 2004, the National Pork Board conducted a workshop to review the current scientific literature pertaining to the well-being of the finisher pig during transportation. The scientific experts concluded that "*At the farm, major factors impacting behavioral and physiological responses of the pig during transport include genetics, slaughter weight, environmental conditions (temperature and humidity), health status, marketing strategy, time off feed, pre-transport experiences, **facility design**, and nature **of handling during loading**"* (Ritter et al., 2005). Therefore, this investigation will provide insight to changes in loading system design that may ultimately lead to the minimization of some stressors that pigs are exposed to at the time of marketing.

References

Anderson, D. B., D. J. Ivers, M. E. Benjamin, H. W. Gonyou, D. J. Jones, K. D. Miller, R. K. McGuffey, T. A. Armstrong, D. H. Mowrey, L. F. Richardson, R. Seneriz, J. R. Wagner, L. E. Watkins, and A. G. Zimmermann. 2002. Physiological responses of market hogs to different handling practices. p. 399 in Proc. Am. Assoc. Swine Vet., Kansas City, MO.

Belk, K. E. J. A. Scanga, G. C. Smith and T. Grandin. 2002. The Relationship Between Good Handling / Stunning and Meat Quality in Beef, Pork, and Lamb. Presented at the American Meat Institute Foundation, Animal Handling And Stunning Conference on February 21-22, 2002

Brown, S. N., T. G. Knowles, L. J. Wilkins, S. A. Chadd, and P. D. Warris. 2005. The response of pigs to being loaded or unloaded onto commercial animal transporters using three systems. Vet. Journal. 170:91-100.

Ellis, M. and M. Ritter. 2006. Impact of season on production: transport losses. Pages 205-207 in Proceedings of the Allen D. Leman Swine Conference, St. Paul, MN.

Ellis, M., F. McKeith, D. Hamilton, T. Bertol, and M. Ritter. 2003. Analysis of the current situation: What do downers cost the industry and what can we do about it? p. 1 in Proc. 4th Am. Meat Sci. Assoc. Pork Quality Symp., Columbia, MO.

Geverink, N. A. A. Kappers, J. A. van de Burgwal, E. Lambooij, H. J. Blokhuis, and V. M. Wiegant. 1998. Effects of regular moving and handling on the behavioral and physiological responses of pigs to preslaughter treatment and consequences for subsequent meat quality. J. Anim. Sci. 76:2080-2085.

Grandin, T. 1993. Livestock handling and transport. Ed T. Grandin, CAB Int.

Grandin, T. 1997. Assessment of stress during handling and transport. J. Anim. Sci. 75:249-257.

Grigor P. N., P. J. Goddard, M. S. Cockram, S.C. Rennie and A. J. Macdonald. 1997 The effects of some factors associated with transportation on the behavioural and physiological reactions of farmed red deer. Applied Anim. Behav. Sci. 52*:* 179-189.

Hails M. R. 1978 Transport stress in animals: A Review. Anim. Reg. Stud. 1*:* 289-313.

Hill, J., N. Berry, and A. Johnson. 2007. Handling and loadout of the finisher pig. Pig FACT sheet. Pork Information Gateway.

Mayes, H. F., and G. W. Jesse. 1980. Heart rate data for feeder pigs. Am. Soc. Ag. Eng. Technical paper. No. 80-4023.

Rademacher, C., and P. Davies. 2005. Factors associated with the incidence of mortality during transport of market hogs. p. 186 in Proc. Allen D. Leman Swine Conf., St. Paul, MN.

Ritter, M., M. Ellis, M. Benjamin, E. Berg, P. DuBois, J. Marchant-Forde, A. Green, P. Matzat, P. Mormede, T. Moyer, K. Pfalzgraf, M. Siemens, J. Sterle, T. Whiting, B. Wolter, and A. Johnson. 2005. The fatigued pig syndrome. J. Anim. Sci. 83(1):258.

Stetzer, A. J., F. K. McKeith. 2003. Quantitative strategies and opportunities to improve quality. Final Report, Benchmarking Value in the Pork Supply Chain. AMSA, Savoy, IL. P1-6.

Trunkfield, H. R., and D. M. Broom. 1990. The welfare of calves during handling and transport. Appl. Anim. Behav. Sci. 28:135-152.

Van Putten, G. and Elshof, W.J., 1978. Observations on the effect of transport on the well being and lean quality of slaughter pigs. Anim. Regul. Stud., 1: 247-27 1.

Von Borell, E., and D. Schaffer. 2005. Legal requirements and assessment of stress and welfare during transportation and pre-slaughter handling of pigs. Livest. Prod. Sci. 97:81-87.

V. Objectives:

Experiment One: Determine if loading system at the farm (traditional chute [T] vs. prototype loading gantry [P]) affects the pigs' welfare parameters at the time of loading.

Experiment Two: Determine if loading system at the farm (traditional chute [T] vs. prototype loading gantry [P]) affects the incidence of dead, injured, or stressed pigs at the packing plant.

Experiment Three: Evaluate the effects of the loading system at the farm (traditional chute [T] vs. prototype loading gantry [P]) on the quality attributes of fresh pork loin between first and close out pulls.

VI. Materials & Methods:

Experiment One - Determine if loading system at the farm (traditional chute [T] vs. prototype loading gantry [P]) affects the pigs' welfare parameters at the time of loading.

Animals and Farms

The protocol for this experiment was approved by the Iowa State University Institutional Animal Care and Use Committee. Finisher pigs (barrows and gilts) from the progeny of PIC sires and Genetiporc females were used. The farm utilized wean-to-finish buildings and pigs were raised in mixed-sex pens. Each barn was environmentally controlled, utilizing a tunnel ventilation system with double pleated non-insulated curtains for emergency ventilation. Flooring was fully slatted and manure was collected in pits below and mechanically removed. Within each barn there were 48 pens housing approximately 24 pigs per pen. Pigs at first pull were provided 0.59 m^2 and at closeout 0.65 m^2 per pig. Pigs were provided ad libitum access to corn-soybean meal diets that met or exceeded National Research Council (NRC) requirements for pigs at various phases of the wean-to-finish production cycle (NRC, 1998). Pigs had continual access to water through a stationary nipple drinker system. Pigs in the first pull were not fed Paylean™ and CO pigs received Paylean™ prior to marketing. Pigs were handled using an internally-approved Swine Welfare Assurance Program™ (SWAP+) market load assessment, which combined the National Pork Board's SWAP program (NPB, 2003) and the American Meat Institute's Animal Handling Audit (AMI, 2005). This assessment included facility evaluation (chute angle and cleat spacing), adherence to the market pig loading standard operating procedure, and transportation standard operating procedure (density and environmental management).

Loading System Design

Two loading system design treatments were compared. **Traditional metal covered chute (T)**: The chute was 76.2 cm in width, 2.3 m in height, and 4.6 m in length, and used square stock (2.5 cm) metal cleats which were spaced 20.3 cm apart. The T chute included a flat pivot section on each end to accommodate the angle that the trailers were positioned relative to the finishing facility. The slope of the chute used to load the pigs onto the trailer was approximately 19 degrees to the bottom deck. The trailer included an internal ramp raised 23 degrees for access to the upper deck. One incandescent lamp fixture (60 watts) was placed at the entrance to the T chute (Figure 1). **Prototype loading gantry (P)**: The loading gantry was constructed of an aluminum covered chute and measured 91.4 cm in width, 3.1 m in height, and 9 m in overall length, including a 7.9 m sloped section and two dual pivoting extension systems that allowed for proper positioning to both the barn and trailer (Figure 2). A cushioned bumper dock system was incorporated into the loading gantry design to completely eliminate gaps from the barn to the loading gantry (Figure 3). The flooring material consisted of metal coated with epoxy (designed to mimic the feel of concrete on the pigs feet) and had an inverted stair step design with cleats 2.5 cm in height and spaced 20.3 cm apart (Figure 4). The gantry slope was approximately 7 degrees to the bottom deck and 18 degrees to the upper deck of the trailer. The P loading gantry utilized an industrial rope lighting system designed to provide a soft, continuous light source that minimized shadowing (Figure 5).

Number of loads

A total of 74 (n = 44 first pull [**FP**], n = 30 closeout [**CO**]) loads were collected from November, 2006 to August, 2007. First pull was defined as the first pigs marketed from the finishing facility and closeout pigs were defined as the last pigs marketed from a finishing facility. Pigs from the FP were provided 0.59 m^2 while pigs from the CO period were provided 0.65 m^2 per pig. First pull; average number of pigs per load = 165.9, average weight per head = 118.9 ± 6.1 kg. Closeout; average number of pigs per load = 161.8, average weight per head = 117.6 ± 5.7 kg.

Welfare Parameters

Welfare parameters were evaluated on individual pigs while in the loading system defined as pigs had exited the finisher barn and prior to entrance into the trailer. Welfare parameters evaluated were electric prod use defined as any time the prod touched the pig. Slips were instances in which normal mechanics of gait were interrupted. Falls were imbalances resulting in contact between a non-limb portion of the body and the ground. Vocalizations were squeals defined as an extended sound (0.5 to 2.0 seconds) of both high amplitude and high frequency produced with an open mouth, indicative of a high level of excitement. Piling was defined as when one or more pigs had either front or rear feet off the ground and on another pig.

Handling Procedures

Pigs were loaded using the integrator standard operating procedure for loading market weight pigs. The same loadout crew (n = 5) was responsible for loading all pigs evaluated in the experiment. The loadout crew received formal classroom and on site training by the company to move and handle finisher pigs in a humane manner. This formal training specified movement in groups of four to six finisher pigs from the pens where they were housed to the trailer used to transport animals to the harvest facility (Figure 6).

Statistical Analysis

All dependent variables were analyzed using PROC MIXED of SAS (SAS Inst., Cary, NC). Fixed effects of chute (traditional or prototype), load number (number of loads in a given night, 6 classes) date, month, barn (8 classes), and complex (17 classes) were fitted along with a random effect of date nested within complex in all analysis models. A linear covariate of number of pigs shipped per load was included in the model.

VII. Results:

Loading system influenced ($P = 0.0001$) all welfare parameters at the time of marketing for pigs in the FP. Pigs loaded on the P chute experienced fewer electric prods, slips, falls, vocalizations, and pile ups. Loading system influenced ($P < 0.01$) all welfare parameters at the time of marketing for pigs loaded in the CO pull (Table 1.1). Pigs loaded on the P chute experienced fewer electric prods, slips, falls, vocalizations, and pileups.

Table 1.1. Subjective welfare parameters from a study evaluating two different loading systems when first pull and close out pigs were marketed (total of 74 loads)

Item	Chute Type		*P*-value
	T	**P**	
First pull (FP)			
No. of loads	**22**	**22**	
Electric prods	161.6 ± 14.1	96.3 ± 12.9	0.0001
Slips	247.9 ± 20.5	96.0 ± 18.9	0.0001
Falls	100.4 ± 9.1	20.2 ± 8.3	0.0001
Vocalizations	138.1 ± 12.1	69.1 ± 11.1	0.0001
Pile ups	3.6 ± 0.5	0.0 ± 0.0	0.0001
Close out (CO)			
No. of loads	**15**	**15**	
Electric prods	188.2 ± 10.5	108.1 ± 12.9	0.0001
Slips	302.5 ± 23.2	106.0 ± 25.7	0.0001
Falls	115.4 ± 13.9	24.8 ± 15.7	0.0001
Vocalizations	140.4 ± 7.6	79.2 ± 9.4	0.0002
Pile ups	4.6 ± 0.4	0.1 ± 0.5	0.0001

VIII. Discussion:

Utilizing a test circuit to evaluate the impact of the loading process on heart rate of pigs moved in social groups of four animals van Putten and Elshof (1978) demonstrated that ascending a loading chute is one of the primary stressors for which the animal is subjected during the loading process. In comparison to other stressors (light changes, descending ramp, funnel, divider, electric prod use) ascending the loading chute was the primary stressor, increasing heart rate to an average of 165 % basic level. This compares with more recent work by Geverink et al., (1998), whom demonstrated that loading/unloading of animals had much greater impact on heart rate than various sound treatments. The angle of an ascending chute significantly impacts the speed of loading and the stress on the animal. In the work by van Putten and Elshof (1978) as ramp angle increased (15, 20, 25, and 30 degrees), heart rate increased linearly from 139 % of basic value to 202 %, while pigs refused to enter a ramp of greater than 30 degrees. More recent work evaluating ramps of 0, 10, 20, 25, 30, 40, 45, and 50 degrees by Warris et al., (1992), supported that ramp angle was critical in determining time of passage. However, there was no significant difference in passage time from 0-20 degrees and while there was a linear relationship above a 20 degree slope there was a significant interaction between slope angle and cleat spacing.

Time required to ascend the 35 degree slope with 150 mm spaced cleats was equivalent to the 20 degree slope with either 150 or 300 mm spaced cleats whereas 35 degree sloped ramps with 300 mm spaced cleats required longer time to ascend. Therefore it is currently recommended that ramp angle should not exceed 20 degrees for a non adjustable ramp and 25 degrees for an adjustable ramp (TQA, 2007)**,** with a cleat spacing of 20 cm or a stair step design with a 6.5 cm rise and a 25 cm run. However, it is worth mentioning that loading and unloading ramps can be avoided entirely by using modular containers or trucks equipped with hydraulic lifts (Brown et al., 2005).

Other important components that may facilitate or hinder loading of pigs are (1) lighting and (2) floor surface. Phillips et al., (1987) demonstrated pigs reared in confinement would move up a ramp illuminated at 80 lux which was similar to their living quarters, but avoided dimly lit or brightly lit facilities. To take advantage of this concept that pigs move towards greater illumination, some facilities, slowly increase the illumination along the alleyways as this minimizes stress and encourages animal movement. However, the lighting system should provide a soft, even, diffuse illumination pattern that minimizes glaring and shadows. It is impossible to properly handle an animal on a slippery surface with poor footing (Grandin, 1997). Research by Applegate et al., (1988) demonstrated significantly increased slippage with flooring materials that had a British Pendulum Number (BPN) less than 60. However, in commercial animal handling systems contamination (i.e. manure or wood shavings) and the loading environment must be accounted for in selecting construction materials and flooring designs. Currently, to overcome animal slippage due to the use of poorly selected flooring materials a very aggressive cleat design is utilized in most loadout chutes, which unfortunately still allows for loss of footing between the cleats and under certain circumstances can result in injury to the dew claws. Grandin (1997) has indicated that pigs have a tendency to move towards a more brightly illuminated area during a loading procedure. This recommendation was supported by Van Putten and Elshof (1978) utilizing a test circuit to demonstrate that pigs will move approximately twice as fast into a lighted rather than into a darker area (16 sec versus 34 sec).

In this study the T loading system in the current study is associated with more intensive handling at the time of marketing as defined by an increased incidence in prods, slips, and falls, vocalizations, and pile ups when loaded regardless if pigs were in the first or close out pulls. Ultimately, this demonstrates that the implementation of the P chute in this system made it possible to minimize the stress placed on market pigs at loadout. In turn if pigs do not flow evenly at the time of marketing the usage of electric prods maybe become more frequent. A previous study by McGlone (2004) demonstrated that the use of electric prods increased the time required for movement, resulting in approximately 15 % of the pigs to "jump" when the electric prod was applied, significantly increased vocalizations, and caused a greater number of fatigued pigs received at the plant. If regular use of an electric prod is needed, the adequacy of the handling facilities should be examined. If a pig is prodded several times in rapid succession its heart rate, body temperature, incidence of open mouth breathing, and blood lactate levels will increase significantly, indicating that the pig is experiencing a stressor(s), which in turn can affect their welfare (Grandin, 1993). Therefore this study begins to show that by manipulating the loading system at the time of marketing improved the welfare of the finisher pig on farm.

References

American Meat Institute. 2005. Recommended animal handling guidelines and audit guide. 2005 ed. Washington, D.C.

Applegate, A. L., S. E. Curtis, J. L. Groppel, J. M. McFarlane and T. M. Widowski. 1988. Footing and gate of pigs on different concrete surfaces. J. Anim. Sci. 66:334-341.

Brown, S. N., T. G. Knowles, L. J. Wilkins, S. A. Chadd, and P. D. Warris. 2005. The response of pigs to being loaded or unloaded onto commercial animal transporters using three systems. Vet. Journal. 170:91-100.

Geverink, N. A. A. Kappers, J. A. van de Burgwal, E. Lambooij, H. J. Blokhuis, and V. M. Wiegant. 1998. Effects of regular moving and handling on the behavioral and physiological responses of pigs to preslaughter treatment and consequences for subsequent meat quality. J. Anim. Sci. 76:2080-2085.

Grandin, T. 1993. Livestock handling and transport. Ed T. Grandin, CAB Int.

Grandin, T. 1997. Assessment of stress during handling and transport. J. Anim. Sci. 75:249-257.

McGlone, J. J. 2005. Inside the mind of the pig. Animal Care and Handling Conference. American Meats Institute (AMI). Kansas City, Kansas. Phillips, P. A., B. K. Thompson, and D. Fraser. 1987. Ramp designs for young pigs. Tech Paper 87-4511. ASAE.

National Pork Board. 2003. Swine Welfare Assurance ProgramTM (SWAPTM). Des Moines, IA.

National Research Council. 1998. Nutrient Requirements of Swine. 10th rev. ed. Natl. Acad. Press, Washington, D.C.

TQA. Trucker Quality Assurance Program™. 2007. National Pork Board. Accessed at www.pork.org on December 12, 2007 .

Van Putten, G. and Elshof, W.J., 1978. Observations on the effect of transport on the well being and lean quality of slaughter pigs. Anim. Regul. Stud., 1: 247-27 1.

Warriss, P. D., E. A. Bevis, J. E. Edwards, S. N. Brown, and T. G. Knowles. 1991. Effect of the angle of slope on the ease with which pigs negotiate loading ramps. Vet. Rec. 28:419-421.

<u>Experiment Two –</u> *Determine if loading system at the farm (traditional chute [T] vs. prototype loading gantry [P]) affects the incidence of dead, injured, or stressed pigs at the packing plant.*

VI. Materials & Methods:

Animals and Farms

The protocol for this experiment was approved by the Iowa State University Institutional Animal Care and Use Committee. Finisher pigs (barrows and gilts) from the progeny of PIC sires and Genetiporc females were used. The farm utilized wean-to-finish buildings and pigs were raised in mixed-sex pens. Each barn was environmentally controlled, utilizing a tunnel ventilation system with double pleated non-insulated curtains for emergency ventilation. Flooring was fully slatted and manure was collected in pits below and mechanically removed. Within each barn there were 48 pens housing approximately 24 pigs per pen. Pigs at first pull were provided 0.59 m^2 and at closeout 0.65 m^2 per pig. Pigs were provided ad libitum access to corn-soybean meal diets that met or exceeded National Research Council (NRC) requirements for pigs at various phases of the wean-to-finish production cycle (NRC, 1998). Pigs had continual access to water through a stationary nipple drinker system. Pigs in the first pull were not fed Paylean™ and CO pigs received Paylean™ prior to marketing. Pigs were handled using an internally-approved Swine Welfare Assurance Program™ (SWAP+) market load assessment, which combined the National Pork Board's SWAP program (NPB, 2003) and the American Meat Institute's Animal Handling Audit (AMI, 2005). This assessment included facility evaluation (chute angle and cleat spacing), adherence to the market pig loading standard operating procedure, and transportation standard operating procedure (density and environmental management). The previously aforementioned loading system design was also compared in experiment Two.

Number of loads

A total of 551 (n = 211 first [FP], n = 340 closeout [CO]) loads were collected from July, 2006 to October, 2007. Pigs from the FP were provided 0.59 m^2 while pigs from the CO period were provided 0.65 m^2 per pig. Average number of pigs per load = 165.9, average weight per head = 118.9 ± 6.1 kg for FP pigs and average number of pigs per load = 161.8, average weight per head = 117.6 ± 5.7 kg for CO pigs.

Loading System Design

Two loading system design treatments were compared. **Traditional metal covered chute (T)**: The chute was 76.2 cm in width, 2.3 m in height, and 4.6 m in length, and used square stock (2.5 cm) metal cleats which were spaced 20.3 cm apart. The T chute included a flat pivot section on each end to accommodate the angle that the trailers were positioned relative to the finishing facility. The slope of the chute used to load the pigs onto the trailer was approximately 19 degrees to the bottom deck. The trailer included an internal ramp raised 23 degrees for access to the upper deck. One incandescent lamp fixture (60 watts) was placed at the entrance to the T chute (Figure 1). **Prototype loading gantry (P)**: The loading gantry was constructed of an aluminum covered chute and measured 91.4 cm in width, 3.1 m in height, and 9 m in overall length, including a 7.9 m sloped section and two dual pivoting extension systems that allowed for proper positioning to both the barn and trailer (Figure 2). A cushioned bumper dock system was incorporated into the loading gantry design to completely eliminate gaps from the barn to the loading gantry (Figure 3). The flooring material consisted of metal coated with epoxy (designed to mimic the feel of concrete on the pigs feet) and had an inverted stair step design with cleats 2.5 cm in height and spaced 20.3 cm apart (Figure 4). The gantry slope was approximately 7 degrees to the bottom deck and 18 degrees to the upper deck of the trailer. The P loading gantry utilized an industrial rope lighting system designed to provide a soft, continuous light source that minimized shadowing (Figure 5).

Truck and Transportation

After loading was complete (Figure 6), pigs were transported ~88.5 km to a commercial packing plant. All animal transport procedures complied with the Transport Quality Assurance Program™ (TQA™; NPB, 2007). All transport trailers were 16.5 m in length, double-deck straight trailers (Barrett Trailers LLC, Purcell, Oklahoma; Wilson Livestock Trailers, Sioux City, IA). All trailers utilized natural ventilation with punched sides and flooring was diamond plate (Figure 7).

Event times

The timing of average loading time, travel time and waiting period at the harvest facility before unloading was recorded. Within each event, the mean, standard deviation, minimum and maximum times (min) were calculated.

Performance Measurements

At the plant, trained and certified personnel unloaded the trailers utilizing docks specifically designed to allow an unimpeded pathway for the pigs from both the upper and lower decks. The trailer side door (2.7 m in width) opened and the receiving dock extended outwards to the truck allowing the pigs to walk straight off the trailer and into the receiving area. Crippled, stressed, and dead pigs were counted at two distinct points; first, when unloading was completed and second, during lairage. Performance measures evaluated at the completion of unloading were crippled on arrival, stressed on arrival, and dead on arrival. Performance measures evaluated in lairage were crippled in plant, stressed in plant, and dead in plant. ***Crippled pigs*** were defined as any pig that had received an injury that impeded its movement. ***Stressed pigs*** were defined a pig that was unable to move or keep up with their contemporaries, but had a reasonable expectation to recover full locomotion with rest. ***Dead pigs*** were defined as a pig that had ceased to breathe. Unloading and lairage defects were summed to evaluate total crippled, total stressed, total dead, and total losses.

Statistical analysis

Due to the fact that dependent variables consisted of observational count (frequencies) data, residual diagnostic checks showed that all dependent variables violated the normality assumptions of ANOVA. All dependent variables were analyzed with the use of PROC GLIMMIX in SAS (SAS Inst., Cary, NC) and data had a poisson distribution. Fixed effects of chute (traditional or prototype), date, month, barn (8 classes), and complex (17 classes) were fitted along with a random effect of date nested within complex. A linear covariate for number of pigs shipped per load was included in the analysis model. The above model is the result of a stepwise process of fitting all 2-way interactions between fixed effects along with second and third order polynomial effects of each covariate and removing non-significant ($P > 0.05$) individual effects sequentially. Additional fixed effects of hauler (trucking firm), driver, and load type (all pigs loaded from the same barn or loaded from two separate barns) along with covariates of load time (time required to complete a load), travel time (time elapsed from the farm to plant), and wait to unload time (time elapsed between arrival at the plant and unloading of pigs) were tested and found not to describe a significant amount of variation for each dependent variable.

VII. Results:

Event times

On average, times for travel to the plant and wait to unload at the plant were similar regardless of chute type used or pull at marketing (Table 2.1). However, load time at the finishing facility was numerically higher for all FP pigs and all pigs loaded using the P chute. The increase in load time for FP pigs can be attributed to the extra time required by caretakers to sort pigs out of their home pen. Additionally, the added load time associated with the P chute can be attributed to realignment of the truck and trailer between loading the upper and lower decks. The average number of pigs shipped per load was higher on loads using the P chute. This difference is due to additional space gained by eliminating the use of the internal ramp when the P chute is utilized.

Performance measures

There was a trend ($P = 0.06$) for loading system to influence the total number of dead pigs during FP. The P loading system did reduce ($P < 0.03$) the number of total losses for pigs from the FP. There were no loading system ($P > 0.05$) differences for any other performance measures for FP or CO (Table 2.2).

Table 2.1. Descriptive statistics for event times during transportation in the Midwest from July, 2006 to October, 2007

	Chute type							
	T				P			
Item	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**
First pull								
Number of loads	**105**				**105**			
Average load size	166.1	4.3	154	176	172.7	5.4	160	176
Average pig live wt, kg	117.7	5.2	105.6	131.9	115.4	5.4	101.2	128.2
Average load time per pig, min	0.25	0.05	0.11	0.43	0.30	0.06	0.16	0.45
Travel time, min	64	9	48	129	61	5	47	74
Wait time, min	6	3	1	18	8	8	2	70
Closeout pull								
Number of loads	**170**				**170**			
Average load size	162.1	5.2	148	176	168.5	8.7	152	176
Average pig live wt, kg	118.3	5.9	102.4	132.7	118.6	6.1	102.2	131.7
Average load time per pig, min	0.23	0.06	0.11	0.44	0.27	0.06	0.09	0.53
Travel time, min	63	8	46	125	62	6	36	89
Wait time, min	7	9	1	49	7	6	1	35

Table 2.2. LSmeans and SE for performance measures at the time of unloading at the plant for the finisher pig when loaded using a traditional or a prototype loading system for first / close out.

	Chute Type		
	T	**P**	
First pull			
Number of loads	**105**	**105**	***P*-value**
Item, %			
Crippled on arrival	0.1 ± 0.0	0.0 ± 0.0	0.33
Stressed on arrival	0.6 ± 0.1	0.5 ± 0.1	0.29
Dead on arrival	0.3 ± 0.1	0.2 ± 0.1	0.16
Crippled in plant	0.0 ± 0.0	0.0 ± 0.0	0.58
Stressed in plant	0.3 ± 0.1	0.2 ± 0.1	0.59
Dead in plant	0.3 ± 0.1	0.2 ± 0.1	0.37
Total crippled	0.1 ± 0.1	0.0 ± 0.0	0.27
Total stressed	0.9 ± 0.1	0.7 ± 0.1	0.23
Total dead	0.6 ± 0.1	0.4 ± 0.1	0.06
Total losses	1.6 ± 0.2	1.2 ± 0.2	0.03
Close out			
Number of loads	**170**	**170**	
Crippled on arrival	0.0 ± 0.0	0.0 ± 0.0	0.41
Stressed on arrival	0.6 ± 0.1	0.5 ± 0.1	0.19
Dead on arrival	0.2 ± 0.0	0.2 ± 0.0	0.86
Crippled in plant	0.0 ± 0.0	0.0 ± 0.0	0.11
Stressed in plant	0.2 ± 0.0	0.2 ± 0.1	0.86
Dead in plant	0.2 ± 0.0	0.1 ± 0.0	0.49
Total crippled	0.1 ± 0.0	0.0 ± 0.0	0.06
Total stressed	0.8 ± 0.1	0.7 ± 0.1	0.29
Total dead	0.4 ± 0.1	0.3 ± 0.1	0.74
Total losses	1.2 ± 0.2	1.0 ± 0.2	0.21

VIII. Discussion:

The percentage of dead pigs at USDA-inspected plants are reported by the Food Safety Inspection Service (FSIS) as "swine condemned ante-mortem for deads", and these national statistics are available to the public via the Freedom of Information Act. The yearly incidence of dead market pigs at USDA-inspected plants for calendar years 1991 through 2006 are presented in Figure 1 (FSIS, 2007). The incidence of dead market swine at U.S. plants was very low in 1991 (0.08%) and 1992 (0.07%); however, the percentage of dead pigs at U.S. plants increased 3-fold between 1993 and 1998 (0.10 and 0.30%, respectively). It is unclear why this value increased greatly over this period, but some potential explanations include changes in genetics, increased slaughter weights, and increased size of production operations (Ellis et al., 2003). For example, the national average for slaughter weights in the U.S. increased from 114.8 kg in 1993 to 117.5 kg in 1999 (USDA-NASS, 2008). From 1998 to 2001, the percentage of dead pigs peaked and remained relatively constant (at 0.28 to 0.30%), whereas, from 2001 to 2002, the percentage of dead pigs at U.S. plants decreased from 0.29 to 0.22%, where it remains today. This decrease might be attributed to greater industry awareness of losses during the marketing process. In 2002, the National Pork Board's Transport Quality Assurance™ program (TQA™) was made available, and there was a concerted focus on research that yielded important knowledge. Beginning about 2005, several pork processors began euthanizing non-ambulatory pigs on the trailer and in the plant that have a low likelihood of recovering (e.g., pigs with broken legs; pigs with a rectal temperature greater than 41.1°C) to minimize stress and suffering. In most cases, non-ambulatory pigs that are euthanized are recorded as dead pigs; therefore, the definition of a dead pig at U.S. processing plants has been altered to now include pigs that are euthanized at the plant. Currently, national statistics are not available for the incidence of non-ambulatory pigs at U.S. processing plants. However, 23 commercial field trials have reported incidences of dead pigs, non-ambulatory pigs, and total losses (dead and non-ambulatory pigs) at U.S. processing plants that occurred before pigs reached the weigh scale. The weighted averages across the 23 field studies (n = 6,660,569 pigs) were 0.25% for dead pigs (range: 0.00 to 0.77%), 0.44% for non-ambulatory pigs (range: 0.11 to 2.34%), and 0.69% for total losses (range: 0.14 to 2.39%). Furthermore, non-ambulatory pigs at the processing plant were classified as fatigued or injured in 18 of these 23 field studies. The weighted averages across the 18 studies (n = 4,966,419 pigs) were 0.37% fatigued (range: 0.05 to 1.98%) and 0.05% injured (range: 0.04 to

0.36%), suggesting a 7:1 ratio of fatigued to injured pigs at the processing plant. Additionally, the percentage of non-ambulatory pigs at the farm was reported in only 12 of the 23 studies (n = 101,417 pigs) and the weighted average for non-ambulatory pigs at the farm across those studies was 0.11% (range: 0.00 to 0.47%; Ritter et al., 2009).

The current trial is in agreement with previous studies when the T system is used to load pigs (1.6 ± 0.2 pigs per load [0.96 %]). However, there were fewer total losses reported when pigs were loaded using the P system (1.15 ± 0.15 pigs per load [0.69%]). Loading system had no (P > 0.05) influence on any measures collected at the plant for pigs in the CO (Table 2.4). However, reported total losses (1.19 ± 0.15 pigs per load, [0.72%], T vs. 0.99 ± 0.15 pigs per load, [0.60%], P) in this study were lower compared to a number of other field studies (Ellis et al., 2003; Hambrecht et al., 2004). FP pigs loaded using the P loading system had fewer total losses at the plant. However, there were no benefits to the P loading system for pigs during the CO period. This investigation has provided data to support changes in facility design that may ultimately lead to the minimization of some stressors that pigs are exposed to at the time of marketing. This study provides additional information influencing welfare and transport losses during marketing and helps to enable targeted interventions to improve both welfare and profitability.

Refernces

American Meat Institute. 2005. Recommended animal handling guidelines and audit guide. 2005 ed. Washington, D.C.

Ellis, M., F. McKeith, D. Hamilton, T. Bertol, and M. Ritter. 2003. Analysis of the current situation: What do downers cost the industry and what can we do about it? p. 1 in Proc. 4th Am. Meat Sci. Assoc. Pork Quality Symp., Columbia, MO.

Food Safety and Inspection Service. 2008. Code of Federal Regulations, Part 313—Humane slaughter of livestock. http://frwebgate6. access.gpo.gov/cgi-bin/PDFgate.cgi?WAISdocID=220135341843+4+2+0&WAISaction=retrieve Accessed Dec. 2, 2008.

Hambrecht, E., J. J. Eissen, and R. I. Nooijen. 2004. Preslaughter stress and muscle energy largely determine pork quality at two commercial processing plants. J. Anim. Sci. 82:1401-1409.

National Pork Board. 2003. Swine Welfare Assurance ProgramTM (SWAPTM). Des Moines, IA.

National Research Council. 1998. Nutrient Requirements of Swine. 10th rev. ed. Natl. Acad. Press, Washington, D.C.

Ritter, M. J., M. Ellis, N. L. Berry, S. E. Curtis, L. Anil, M. Benjamin, E. Berg, D. Butler, C. Dewey, B. Driessen, P. DuBois, A. Green, J. Hill, J. Marchant-Forde, P. Matzat, J. McGlone, P. Mormede, T. Moyer, K. Pfalzgraf, J. Salak-Johnson, M. Siemens, J. Sterle, C. Stull, T. Whiting, B. Wolter, S. R. Niekamp, and A. K. Johnson. 2009. Transport losses in market weight pigs: Definitions, incidence and economic impact. *Accepted in the Professional Animal Scientist.*

USDA-National Agricultural Statistics Service. 2008. Agricultural prices—2006 summary. http://usda.mannlib.cornell. edu/MannUsda/viewDocumentInfo. do?documentID=1003 Accessed Nov. 2, 2008.

<u>Experiment Three:</u> Evaluate the effects of the loading system at the farm (traditional chute [T] vs. prototype loading gantry [P]) on the quality attributes of fresh pork loin between first and close out pulls.

VI. Materials & Methods:

Animals, Farm Site, and Pig Handling

The protocol for this experiment was approved by the Iowa State University Institutional Animal Care and Use Committee. Finisher pigs (barrows and gilts) from the progeny of PIC (Hendersonville, TN) sires and Genetiporc (Alexandria, MN) females were used. The farm utilized one wean-to-finish growing facility and pigs were raised in mixed sex pens (~24 pigs per pen). Each barn was environmentally controlled, utilizing a tunnel ventilation system with double pleated non-insulated curtains for emergency ventilation. Flooring was fully slatted and manure was collected in pits below and mechanically removed. Pigs were provided *ad libitum* access to corn-soybean meal diets that met National Research Council (NRC) requirements for pigs at each phase of the wean-to-finish production cycle (NRC, 1998). Pigs had *ad libitum* access to water through a stationary nipple drinker system. All pigs were loaded using sort boards and five pigs were moved from the home pen to the trailer at a time. A single loadout crew consisting of five persons was responsible for loading all pigs.

Truck and Transportation

After loading was complete, pigs were transported ~88.5 km to a commercial packing plant. All animal transport procedures including stocking densities and trailer boarding and bedding requirements complied with the Transport Quality Assurance Program™ (NPB, 2007). All trailers were 16.5 m in length had two straight naturally ventilated decks and flooring was diamond plate (Barrett Trailers LLC, Purcell, Oklahoma; Wilson Livestock Trailers, Sioux City, IA; Figure 7).

Trial A – first pull (FP)

First pull refers to the first group of pigs marketed from a finishing facility (average weight per pig; 111.7 ± 1.9 kg).These pigs would not have been feed ractopamine hydrochloride (trade name: Paylean®; Elanco Animal Health, Greenfield, IN) prior to harvest. A total of 200 pork loins were collected in January (2007) from pigs loaded with the T (n = 100) or the P loading system (n = 100) over two loads (one type of loading system per load as this was the only practical way of loading pigs onto the truck).

Trial B – closeout pull (CO)

Close out was defined as the last pigs marketed from a finishing facility (average weight per pig; 131.5 ± 1.7 kg). These pigs were fed ractopamine hydrochloride (trade name: Paylean®; Elanco Animal Health, Greenfield, IN). A total of 240 pork loins were collected in February (2007) from pigs loaded with either the T (n = 120) or the P loading system (n = 120) over two loads (one type of loading system per load as this was the only practical way of loading pigs onto the truck).

Processing

Pigs were harvested at a commercial facility on two processing days (day one = 200 FP pigs, day two = 240 CO pigs). Both treatments were presented on each harvest date. Pigs were held in lairage for 4-h, and food was withheld; however, pigs had continual access to water. A CO_2 anesthetizing system was used to render the pigs unconscious. The carcasses were held in a blast-chiller for a period of approximately 90 min (Huff-Lonergan and Page, 2000). Following the blast-chill, carcasses were held in a conventional cooler until fabrication 24 h postmortem.

Fresh Pork Quality Attributes

Initial pH (~35 min postmortem) was measured at the 10th rib of the same *longissimus dorsi* (LD) of each carcass prior to entering the blast chill chamber. A 24 h pH was evaluated on the same muscle and at the same location on the carcass. Both measures were collected using a Hanna 9025 pH / ORP meter (Hanna Instruments, Woonsocket, RI), which was calibrated at the expected carcass temperatures. The carcasses remained in the cooler until 24 h postmortem, after which time they were fabricated. The objective (CIE L*), and subjective Japanese Color Score (JCS cut and JCS rib) values were determined on the LD by personnel that were both trained and experienced in subjectively evaluating quality of pork carcasses. Objective Japanese Color Score was determined using a Minolta CR-400 Chroma Meter (Minolta Camera Co., Ltd., Japan) with illuminant C and 20 standard observer. Color measurements (L* values) were measured on a cross-section of the LD at the last rib. Subjective color was evaluated using the JCS system consisting of six plastic discs that ranged from scores of 1 to 6 (1=pale grey, 6=dark purple; Nakai et al., 1975). Japanese color scores were obtained from the outer surface lean (JCS cut values) of the LD and from the cross-section of the LD at the last rib (JCS rib values). All measures were collected on the left side of the pig's carcass (Gardner et al., 2006).

Statistical Analysis

The experimental unit was the pork loin and a complete randomized experimental design was utilized. The statistical model included the parameter of interest (initial pH, 24 h pH, JCS cut score, JCS rib score and loin L*), treatment (traditional [T] or prototype [P]) and gender (barrow or gilt). Data were analyzed using the PROC MIXED of SAS® (SAS Inst., Cary, NC). Harvest date was a covariate (two harvesting dates). There were no main effects of gender or treatment by gender interaction and subsequently these were removed from the final model. A *P*-value of $P \leq 0.05$ was considered significant.

VII. Results:

Trial A – first pull

There were no difference between treatments for JCS rib values ($P = 0.20$). Loins from pigs loaded with the P loading gantry had higher ($P < 0.05$) initial and 24 h pH and tended ($P = 0.08$) to have higher JCS cut values. These observations were consistent with lower ($P = 0.03$) Loin L* values observed in loins from pigs loaded with the P loading gantry (Table 3.1)

Trial B – closeout pull

There were no difference between treatments for initial pH and JCS cut values ($P > 0.05$). Loins from pigs loaded with the P loading gantry had higher ($P = 0.01$) 24 h pH and JCS rib values. Pigs loaded on the P loading gantry tended to have lower ($P = 0.06$). Loin L* values (Table 3.1).

Table 3.1. Subjective and objective fresh pork loin quality attributes from a study evaluating two different loading systems when pigs are marketed.

Item	Chute Type		*P*-value
	T	P	
Trial A- First Pull			
No. of animals	100	100	
Initial pH	6.47 ± 0.02	6.53 ± 0.02	0.05
24 h pH	5.70 ± 0.01	5.74 ± 0.01	0.02
JCS cut values	3.1 ± 0.04	3.2 ± 0.04	0.08
JCS rib values	3.3 ± 0.05	3.2 ± 0.05	0.20
Loin L*	46.72 ± 0.31	45.74 ± 0.31	0.03
Trial B - Closeout Pull			
No. of animals	120	120	
Initial pH	6.48 ± 0.03	6.51 ± 0.03	0.35
24 h pH	5.70 ± 0.01	5.74 ± 0.01	0.01
JCS cut values	3.1 ± 0.04	3.2 ± 0.04	0.10
JCS rib values	3.1 ± 0.04	3.3 ± 0.04	0.01
Loin L*	46.78 ± 0.38	45.76 ± 0.38	0.06

VIII. Discussion:

How individual pigs cope with aversive stressors has been shown to detrimentally affect the quality of pork (Grandin, 1997) and in turn the profitability. Problems with color (two-toning, dark, firm, and dry), bruising, and pale, soft, and exudative (PSE) meat has been estimated to cost the U.S. swine industry $254,104,500 or $2.44 per finisher head per year (Stetzer and McKeith, 2003). Grandin, (1999) reported approximately 10 % more pork would be suitable for high quality exports to Japan if pigs are handled quietly. Pigs marketed at first pull are subjected to additional handling stress when removed from their home pen environment, due to the sorting. In contrast, pigs marketed at close out are all removed from their home pen at once with no differential selection, potentially eliminating the stress due to sorting market ready pigs from the pen. In this study, despite the rigors of extra handling during sorting from the pen during first pull, pigs loaded using the P loading gantry had superior meat quality attributes. In addition, pigs loaded with the P loading gantry on both experiments had improved 24 h pH, and overall color attributes. In conclusion, this investigation begins to demonstrate that loading system design contributes to positive fresh pork quality attributes. This investigation has provided insight to changes in facility design that may ultimately lead to the minimization of some stressors that pigs are exposed to at the time of marketing. Results indicate that pigs loaded on the P chute during the FP have fewer total deads and total losses.

References

Gardner, M. A., E. Huff-Lonergan, L. J. Rowe, C. M. Schultz Kaster, and S. M. Lonergan (2006): Influence of harvest processes on pork loin and ham quality J. Anim. Sci. 84:178-184.

Grandin, T. 1997. Assessment of stress during handling and transport. J. Anim. Sci. 75, 249-257.

Huff-Lonergan, E. and J. Page (2000): Chilling effects on quality. Meat Processing pp. 54-56. -11.

National Pork Board. NPB. 2007. Transport Quality Assurance Program™ (TQA™).

National Research Council. 1998. Nutrient Requirements of Swine. 10th rev. ed. Natl. Acad. Press, Washington, D.C.

Stetzer, A. J., F. K. McKeith. 2003. Quantitative strategies and opportunities to improve quality. Final Report, Benchmarking Value in the Pork Supply Chain. AMSA, Savoy, IL. P1-6.

Figure 1. Traditional metal covered chute (T)

Figure 2. Prototype loading gantry (P):

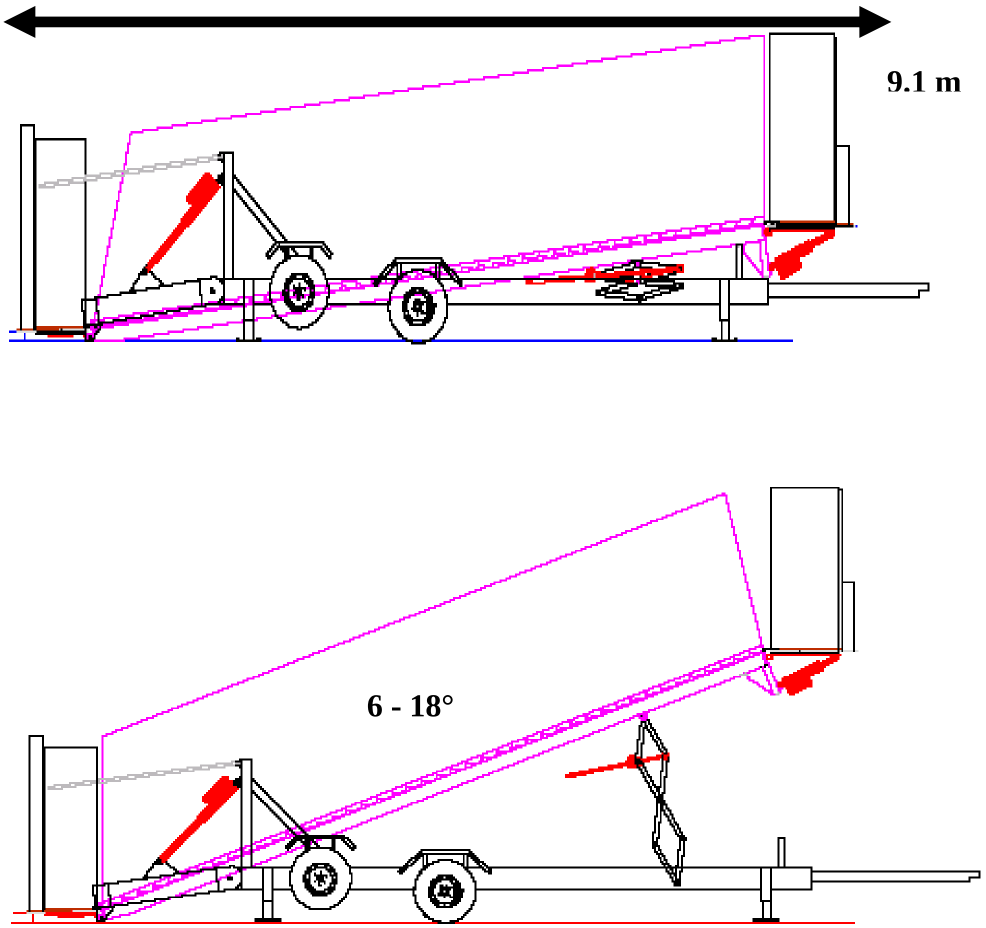

Figure 3. Unique bumper dock system

Figure 4. Vanberg Epoxy: G-diamond grit. Stair step 17.2 com tread width and 5.1 cm step height

Figure 5. Lighting and stair wall color

Figure 6. Loading pigs with the prototype loading system

Figure 7. External and internal view of the straight deck trailers used to haul pigs.

Publications, presentations or abstracts from the project:

Meetings:

Hill, J. N. Berry and A. K. Johnson. 2006. Handling and loadout: The complex interaction between the pig, caretaker and the facility. Pork Academy, National Pork Board.

Johnson, A. K. 2007. Hosted the Japanese Ministry of Agriculture Fisheries and Food and National Pork Producers Council from Washington D.C. Spoke about the swine well-being research initiatives, teaching and extension activities as well. Students: Berry, Fitzgerald and Goldsmith presented, in addition Dr. K. Stalder presented the sow productive lifetime posters and the extension related activities. April 11th 2007.

Berry, N. A. Johnson, J. Hill, T. Baas, L. Karriker and K. Stalder. 2007. Loading gantry versus traditional chute for the finisher pig: Effect on welfare parameters at time of marketing. Invited talk by the National Pork Board to the Allen D. Leman Swine Conference September 15-18, 2007. St. Paul, MN. Proceedings pages 137.

Pork Information Gateway:

Hill, J., N. Berry and A. K. Johnson. 2007. Marketing the finisher pig: The impact of facility design. Pork Information Gateway. PIG 09-08-01.

Hill, J., N. Berry, and A. K. Johnson. 2007. Handling and loadout of the finisher pig. PIG 09-08-02.

Animal Industry Reports through Iowa State University:

Berry, N. L. A. K. Johnson, T. J. Baas, K. J. Stalder, and L. A. Karriker. 2007. Loading gantry versus traditional chute for the finisher pig: effect on transportation and packing plant losses. A. S. R2339.

Berry, N. L., A. K. Johnson, T. J. Baas, K. J. Stalder, and L. A. Karriker. 2007. Loading gantry versus traditional chute for the finisher pig: effect on welfare parameters at time of marketing. A. S. R2338.

Media:

Berry, N. L., A. K. Johnson, T. J. Baas, K. J. Stalder, and L. A. Karriker. 2007. Loading gantry versus traditional chute for the finisher pig: effect on welfare parameters at time of marketing. December 15th, 2007 P24 -25.

Berry, N. L., and A. K. Johnson. 2008. New handling strategies. Farms.com. The Benchmark Magazine. 3:30-31.

Peer review abstracts:

Berry, N., A. Johnson, K. Stalder, T. Baas and L. Karriker. 2007. Loading gantry versus traditional chute for the finisher pig: Effect on transportation and packing plant losses. J. Anim. Sci. 86(1): 612 (Abstr.)

Berry, N. L., A. K. Johnson, J. Hill, T. Baas, L. Karriker, and K. J. Stalder. 2007 (Abstr). Loading gantry versus traditional chute for the finisher pig: Effect on welfare parameters at time of marketing. J. Anim. Sci. 86(1):612.

Berry, N., A. Johnson, J. Hill, T. Baas, L. Karriker and K. Stalder. 2007. Loading gantry versus traditional chute for the finisher pig: Effect on welfare parameters at time of marketing. The 60th Annual Reciprocal Meat Conference June 17-20, 2007 - Brookings, South Dakota.

Karriker L, A. Johnson, k. Stalder, and N. Berry. Session 5537: Manipulating transport for improved well-being. Invited. Conference Notes CD of the 145th American Veterinary Medical Association Meeting. July 19-22, 2008. New Orleans, Louisiana.

PhD Thesis:

Berry, N. L. 2007. Loading system effect on performance, handling and meat quality attributes of finisher pigs. A dissertation submitted to the graduate faculty in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY. Major: Animal Science. Program of Study Committee: T. Baas, A. Johnson, L. Karriker, J. Kliebenstein, S. Lonergan, and K. Stalder.

Peer review papers

Fitzgerald, R. F., K. J. Stalder, J. O. Matthews, C. M. Schultz Kaster, and A. K. Johnson. 2008. Factors increasing fatigued, injured, and dead pig frequency during transport and lairage at a commercial abattoir. Journal of Animal Science. 87: 1156-1166.

Ritter, M. J., M. Ellis, N. L. Berry, S. E. Curtis, L. Anil, M. Benjamin, E. Berg, D. Butler, C. Dewey, B. Driessen, P. DuBois, A. Green, J. Hill, J. Marchant-Forde, P. Matzat, J. McGlone, P. Mormede, T. Moyer, K. Pfalzgraf, J. Salak-Johnson, M. Siemens, J. Sterle, C. Stull, T. Whiting, B. Wolter, S. R. Niekamp, and A. K. Johnson.˙ 2009. Transport losses in market weight pigs: Definitions, incidence and economic impact. Accepted in the Professional Animal Scientist. 2009.

Coming in 2010:

Animal Industry Reports through Iowa State University:

Berry, N. L., A. K. Johnson, S. M. Lonergan, T. J. Baas, J. Hill, C. Schultz-Kaster, N. Matthews, L. Karriker and K. J. Stalder. 2009. Loading Gantry versus Traditional Chute for the Finisher Pig: Effect on fresh pork quality attributes when properly loaded at First Pull. *Submitted in November 2009 for possible publication as an Animal Industry Report.*

Berry, N. L., A. K. Johnson, S. M. Lonergan, T. J. Baas, J. Hill, C. Schultz-Kaster, N. Matthews, L. Karriker and K. J. Stalder. 2009. Loading Gantry versus Traditional Chute for the Finisher Pig: Effect on fresh pork quality attributes when properly loaded at Close Out. *Submitted in November 2009 for possible publication as an Animal Industry Report.*

Peer review paper:

Berry, N. L. A. K. Johnson, S. M. Lonergan, T. J. Baas, J. Hill, C. Schultz-Kaster, J. O. Matthews, L. A. Karriker and K. J. Stalder. 2008. Loading gantry versus traditional chute for the finisher pig: Effect on fresh pork quality attributes when properly loaded. Fleischwirtschaft.

Berry, N. L. A. K. Johnson, S. M. Lonergan, T. J. Baas, J. Hill, C. Schultz-Kaster, J. O. Matthews, L. A. Karriker and K. J. Stalder. 2008. Loading gantry versus traditional chute for the finisher pig: Effect on fresh pork quality attributes when incorrectly loaded. Fleischwirtschaft.

Hill, J., N. L. Berry, J. Harmon, L. A. Karriker, K. J. Stalder, A. K. Johnson. 2009. Developing The Next Generation: A Loading System Designed for the Market-weight Pig. ASAE.

Berry, N., A. K. Johnson, S. Lonergan, T. J. Baas, J. Hill, L. A. Karriker and K. J. Stalder. 2009. Loading gantry versus traditional chute for the finisher pig: Effect on stress responses at the time of loading and marketing losses at the plant. Journal of Animal Science.