RESEARCHREPORT
ANIMAL WELFARE

Title: Impact of Auto-sort Systems on Pig Welfare, **NPB #06-053**

Investigator: Janeen L. Salak-Johnson, PhD

Institution: University of Illinois

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II. Industry Summary: A series of studies were designed to determine any impact of various autosort layouts on pig productivity and welfare. To accomplish this, Exp 1, we compared food-court, fast-lane, and water-pen layout to large conventional pens; Exp 2, based on data from Exp 1, we compared the impacts of food-court layout with large and small conventional pens; and Exp 3, based on data from Exp 1 and 2, we evaluated the impact of feeder-type and resource placement within pen.

Overall, pigs from auto-sort systems are easier to handle, load and unload compared to pigs from both large and small conventional pens. Pigs from large conventional pens are easier to handle than are pigs from small conventional pens. Maintenance behaviors, especially eat-drink sequence and aggressive encounters are influenced by auto-sort layouts, with the greatest amount of aggression occurring within the food-court layout in the finish phase when resources become limiting. Majority of aggressive encounters occur around the waterers. Feeding bouts and length of feeding bouts as well as number of pigs either eating or drinking are influenced by the auto-sort layout. Moreover, there is a learning curve for training and management of pigs in auto-sort systems, but for the pig it is a rather "quick learning curve" especially if all equipment is functioning properly. Adequate training is essential for all auto-sort layouts and sometimes pushing pigs through the system is more important for some of the layouts than it is for others. For example, in fast-lane layout, if pigs are not forced to move through the system or lack motivation to move, the consequences are apparent at sorting time – hence greater sort loss due to heavy pigs. Also, in our study, pigs that are less "motivated" to move (e.g., water-court) do not eat or drink as often, which may explain the lag in growth among pigs from water-court pens. Overall, there were positive and negative attributes associated with all of the systems used in this study; with most of the "positive" attributes being associated with food-court (e.g., better feed efficiency, least sort loss). However, there were "negative" attributes associated with food-court, such as an increase in aggressive behavior especially during late finish-phase when resources appear to be limiting. Moreover, there was a slow-down in growth as we "closed-in" on the first sort, which may be due to this increased aggression. This is most likely a – "design flaw" problem.

Based on data from 1st study, we designed a 2nd study that evaluated the impact of food-court pens in comparison to either small or large pen conventional on pig performance and welfare. Pigs from food-court pens handled better and were less stress-responsive to handling/transportation than were pigs from either small or large conventional pens. From this perspective pigs from food-court pens were better able to cope with certain stressors than were pigs from either small or large conventional pens. Among conventional pens, pigs from small pens were harder to handle/load and seemed to be more "stressed" than were pigs from large pens.

In a 3rd study, we evaluated the impact that feeder-type and resource placement had on performance and welfare. Feeder-type and placement did have an impact on various measures in this study. Aggression was reduced during the late-finishing phase among pigs in pens with access to wet-dry feeders. Feeder-type also affected handling; pigs from pens with wet-dry feeders handled better (especially removal from pens) than did pigs from pens with dry feeders. Placement of resources had an impact on the "stress response" of these pigs; pigs from pens with new feeder placement had less of a stress response than did those pigs with original feeder placement, thus these data may support our hypothesis that feeder-type and placement of resources may affect pig well-being. Performance was similar, but wet-dry feeder with new feeder placement tended to perform better than all other treatment groups. However with only one replicate and the fact that there was a "learning curve" for the manager of the farm to learn to use the new feeders, this may have impacted the results early on in this study. We hypothesized that the pigs in the pens with wet-dry feeders would have out-performed pigs with dry feeders.

Overall, there are benefits that can be gained from an auto-sort system, but management and auto-sort design must be further investigated and optimized to reap all possible benefits. Pig productivity and well-being have major influences on sustainability and profitability of any pork-production operation. This research project provides producer with scientific data that supports the concept that auto-sort systems can have an impact on the performance and well-being of wean-to-finish pigs. The "biggest" benefit as of right now is that even in a non-optimized auto-sort system pigs are easier to handle/load and unload and the total amount of time it takes to move and load pigs is significantly reduced when pigs are kept in an auto-sort system. The food-court layout does appear to be the most viable layout, but the best management scheme, the best layout, and the best "physical components" that make up the system need to be further identified. Furthermore, other layouts can be optimized as well but the various components of the system need to be evaluated and identified. It is obvious from these data that layout, feeder-type, resource placement, and management are extremely important factors that must be considered to gain the most benefits from this technology. Moreover, it is apparent that an optimized and well-managed auto-sort system can improve pig well-being. johnso17@illinois.edu

III. Scientific Abstract:

Auto-sort technology was a relatively fast-growing, behavior-based production system that was implemented by early adopters without a full understanding of the impact these systems could have on pig productivity and well-being. Thus, we designed a series of studies that would provide producers with science-based information that would enable them to optimize these systems without unwittingly compromising pig well-being. The objectives of these studies were to assess the impact that various auto-sort layouts had on pig behavior, performance and overall well-being and to optimize an auto-sort system that could improve pig productivity and well-being. To accomplish these objectives a series of experiments were designed to: (**1**) investigate the impact that 3 different auto-sort layouts had on pig performance and well-being. These layouts (600 pigs per pen) consisted of (**a**) **food-court (**~40% of total floor space = "food-court"), (**b**) **water-pen (**~15% of total floor space = "water-pen"), (**c**) **fast-lane (~**12.5% of floor space/"zone"), and (d) **control (**large pens; 300 pigs/pen; 2 pens); (**2**) determine impact of food-court on performance and well-being when compared to (~600 pigs/ layout; 2 food-courts) both large conventional pens (300 pigs/pen; 2 total pens; ~600 pigs) and small conventional pens (35-40 pigs/pen = ~600 pigs); and (**3**) further optimize a food-court by investigating the impact of feeder type (**dry feeder** vs. **wet/dry feeder**) and feeder placement – **original placement** (2 sets of feeders in straight line) vs. **new placement** (feeders scattered) on pig productivity and well-being. Exp 1, regardless of auto-sort layout all pigs learned quickly to use the system. Auto-sort layout did affect time it took to enter and exit scales; pigs in water-pen took longer to enter scales during training process but exited quicker than did pigs from food-court or fast-lane ($P < 0.05$). Pigs from water-pen spent more time lying in scale during training process than did pigs in the other auto-sort systems ($P < 0.05$). Upon removal from pens and during loading, pigs in large pens vocalized and reared more than did pigs from auto-sort pens ($P < 0.01$). Prod use was less among auto-sort pigs than pigs from large pens ($P < 0.001$). Pigs from food-court were less difficult to handle while loading on truck than all other groups ($P < 0.01$). Total loading time was greater for pigs from large pens than any of the auto-sort groups ($P \leq 0.05$). Pigs from fast-lane loaded faster than did pigs from water-pens ($P < 0.05$). Behavioral patterns/sequences were significantly influenced by auto-sort layout. Specifically, number of pigs eating at once was greatest in food-court but, least in large pens and water-pens ($P < 0.001$). Duration of eating was greatest among pigs in food-court than fast-lane or water-pen ($P < 0.05$). Pigs in food-court and large pens performed more ear bites than did pigs in fast-lane ($P < 0.01$). Pigs in large pens engaged in more dyadic fighting bouts than did pigs in the fast-lane or water-pen ($P < 0.05$). But, pigs in food-court had the greatest duration and frequencies of aggressive encounters ($P < 0.01$). Pigs in water-pen were least active overall compared to pigs in other auto-sorts ($P < 0.05$). Among all pigs there was a shift in leukocyte population and cortisol in response to handling, loading and transportation; the magnitude of change was less among auto-sort pigs ($P < 0.01$). Percentage neutrophils was less in pigs from food-court and fast-lane post-transportation than pigs from water-pen or large pens ($P < 0.001$). Plasma IGF-1 was higher pre- and post-transportation in pigs from food-court than other treatment groups ($P < 0.05$). Pigs from food-court were more efficient and had less sort loss than all other treatment groups. Exp. 2, pigs from food-court handled and loaded better than did pigs from either small or large pens ($P < 0.05$). Pigs from large pens were less difficult to handle and loaded better than did pigs from small pens ($P < 0.05$). Thus, pigs from large and small pens vocalized and reared more, required more prod use and took more time to load than did pigs from food-court ($P < 0.05$). Pigs from food-court showed less stress response than did pigs from large and small pens ($P < 0.05$). Exp 3, training was similar regardless of feeder type or placement. Pigs in pens with dry feeders had longer bouts of aggression than did pigs in pens with wet-dry feeders ($P < 0.01$). Pigs from pens with dry feeders also vocalized more upon removal from pens and during loading ($P < 0.05$) and those from pens with dry feeders and original feeder placement required more prod used ($P < 0.10$). Feeder placement influenced immature neutrophils, with pigs in pens with new placement had greater percentage than did those in pens with old ($P < 0.05$) but they tended to have lower cortisol post-transportation. Taken together, these data indicate that there are benefits associated with auto-sort systems based on measures of productivity, handling, behavior and overall well-being. Moreover, these data imply that feeder type and feeder placement can improve pig well-being.

IV. Introduction:

Pork producers and consumers are concerned about any impact of production environments and management practices on pig well being and performance. The productivity and welfare of the pig has major influences on sustainability and profitability of a pork-production operation. Effects of production systems on the pig is a major public issue, driven primarily by public perceptions and regulations promulgated in Europe, not by science. Ironically, forcing producers to make unwise changes in their production systems could unwittingly compromise pig welfare. Moreover, activists and consumers are demanding that producers ensure the highest state of being of the pigs in their “charge”. It is important that producers have at hand scientifically developed optimal production schemes and systems that will enable the industry to improve the health, productivity, and reproductive efficiency of the individual pig while sacrificing neither well being nor profitability. We must gain information on animal well being and economic implications of alternative production systems if we are to be in a position to make decisions that will enable us to optimize behavior-based production technology such as auto-sort in terms of animal health, performance, and overall well being, while maximizing profitability.

Scientific literature reporting any impact of an auto-sort system on pig well being essentially does not exist. Largely anecdotal trade-press reports provide claims of substantial benefits of auto-sort technology at load-out time in many operations and possible welfare benefits, but there is little information to help producers to understand how to implement such a system or to decide which of the currently available new-construction or retrofit layouts to use. In fact, many of these decisions are being driven by the companies designing the equipment and systems. In summary, the trade-press reports that exist have implied that the auto-sort floor layouts have economical benefits due to reduced sort loss and less labor. Others have reported that during transport fewer death losses are recorded among pigs that are managed in an automatically sorted barn (0.11 %) compared to those managed in a conventional finish environment (0.21%). Still, others have claimed that these systems provide an opportunity to increase the throughput and sell more hogs at the top weight range—a 1000 head producer can potentially gain $7,000-10,000 per year. There have also been claims that the auto-sort system reduces tail biting, fighting, and death loss; thus welfare is improved. Moreover, these anecdotal trade-press reports conclude from an economical standpoint – that there is better uniformity in size of pigs produced, accurate marketing is enhanced, labor savings realized, and improved feeding and throughput achieved (Vansickle). However, despite these claims there appears to be drawbacks associated with automatic sorting systems – 1) a learning curve comes with owning an auto-sort system, 2) the system can increase the overall cost of your building, 3) durability issues, and 4) limited research data exist at this point (Vansickle, 2003). But more importantly, no scientific information exists about these systems to guide producers in terms of pig welfare and performance or operation sustainability at times other than preparation for load-out. It is imperative that producers understand the biologic and well being implications of the auto-sort system, because if a pork-production system is biologically infeasible, then concerns about its economics and well being impacts will be moot.

There are many factors including (but not limited to) equipment design, environment, genetics, management, nutrition, **STRESS**, and so forth—that may influence the overall behavior, performance, health and productivity of pigs grown in these various auto-sort systems. In fact, one of the biggest factors that may influence the success or failure of these auto-sort systems is social stress. Social stress undoubtedly has an impact on pig performance and overall well being but unfortunately is generally ignored as a potential factor that influences pig performance. Thus, it is essential that we begin to unravel and come to understand the most important factors that contribute to performance, productivity, and well being of the animals being kept in these auto-sort systems, so that these systems can be optimized; regardless of the genetics, management, environment, and so on. They must work for everyone. At present, many producers are very much interested in auto-sort technology, but have two big questions about this behavior-based system: (1) Does improved pig growth rate, feed-conversion efficiency, health, and fewer downer incidents during transportation and at the abattoir result from employing an auto-sort system throughout the grow-finish phase? (2) Do results of benefit/cost analyses indicate that the auto-sort system used during grow-finish is economically feasible?

V. Objectives: Broad-range objectives

1. *Differential behavioral ethograms will be developed for pigs in 4 experimental auto-sort layouts – referred to as conventional pen, food-court, water-court, and alley/lane wean-to-finish layouts.*
2. *Individual behavioral ethograms will be developed for sub-samples of pigs in several wean-to-finish layouts based on individual low, average, and high performance. *<u>Did on a group basis could not do on individual pig basis so combined objective with 1.</u>*
3. *Routine performance parameters, handling, and carcass-quality scores will be evaluated.*
4. *Physiologic analyses will be employed to further determine (in appropriate sub-samples of pigs) any impacts of several production systems on pig performance, carcass quality, and overall pig welfare.*

VI. Materials & Methods:

**Note-These experiments enabled us to address objectives 1-4, with the exception of data collection at individual pig level*

<u>Experiment 1</u> – 3 replicates. Experiments were conducted to investigate the impact that 3 different auto-sort layouts had on pig performance and well-being. These auto-sort layouts consisted of: (**a**) **food-court**; ~40% of total floor space was "food-court" area (pigs go through scale to enter "food area"; water throughout entire space); (**b**) **water-pen**; ~15% of total floor space was "water-pen" area (pigs enter scale from water-pen to reach "food area", no water in food area), and (**c**) **fast-lane**; 12.5% of floor space per zone (scale entry at last zone in order to go back through system; no feed available; food and water in each "zone"). The **control** was a large pen conventional (300 pigs per pen; 2 pens). Total number of pigs = ~7200 wean-to-finish pigs.

****Note-aspects of all of these experiments especially, data from Exp 2 and 3 are additional information that was provided by resources obtained from Illinois Pork Producers Association as well. These series of experiments where designed based on results from Exp1, since some of these data are relevant to objectives outlined in this proposal we are sharing with NPB so that we can provide the most complete data set.***

<u>Experiment 2</u> was designed based on data from Exp 1. Based on scientific data, we determined that the food-court layout may provide the most benefits, thus we chose to further evaluate that particular system. In the first 3 replicates we determined that the most valid control was large conventional pens (300 pigs per pen), thus we wanted to evaluate food-court layout against both large and small conventional pens. **In exp 2** – 1 replicate, an experiment was conducted to compare food-court (~600 pigs per layout; 2 food-courts) with both large conventional pens (300 pigs/pen; 2 total pens; ~600 pigs) and small conventional pens (35-40 pigs per pen = ~600 pigs). Total number of pigs = 2400 wean-to-finish pigs

<u>Experiment 3</u> was designed to further optimize a food-court auto-sort system. Thus, we hypothesized that not only is management an important component of the auto-sort system (based on our data) but so are the various physical components that make-up an auto-sort system – the two components we choose to evaluate (based on our hypothesis) was feeder-type and location of resources within the "food area". **In exp 3** – 1 replicate, an experiment was conducted to further optimize a food-court by investigating the impact of feeder type (**dry feeder** vs. **wet/dry feeder**) and feeder placement – **original placement** (2 sets of feeders in straight line (8 total feeders; 12 waterers) vs. **new placement** (feeders scattered (no straight line) 8 total feeders; 12 waterers) on reducing aggressive behavior thus improving performance, productivity and well-being. Total number of pigs = 2400 wean-to-finish pigs.

VII. Results and Discussion:

Experiment 1: Food-court, Fast-lane, Water-court, and Conventional large pen (3 replicates).

NOTE: all data presented are significant at P < 0.05, unless specifically stated that data were not statistically analyzed.

Differential behavioral ethograms were developed for pigs in experimental auto-sort layouts – food-court, water-court, and alley/lane wean-to-finish layouts.

Effects of auto-sort on behavioral ethogram of wean-to-finish pigs

Data were collected to evaluate various behaviors such as **maintenance**, **aggression, and overall activity.** Observing these various behaviors was important because these behaviors even in confinement can increase energy requirements of a pig. Number of pigs and amount of time spent engaged in activities (e.g., walking, standing, eating, etc.,) were all influenced by auto-sort layout. More pigs at once (or larger groups of pigs) were observed engaged in various "behavioral activities" in the food-court pens, while smaller groups of pigs (at one time) were observed within large conventional pens. Pigs in large conventional pens spent significantly more time standing than did pigs in food-court pens. Larger groups of pigs were observed lying in the food-court at one time than any other treatment group. Pigs were observed more often running in fast-lane and water-court pens compared to pigs in conventional pens. But, pigs in conventional pens spent more time running than did pigs in food-court pens.

Eating behavior (no. pigs eating, frequencies and durations) was significantly influenced by auto-sort layout. Pigs in food-court and fast-lane auto-sorts were observed eating more (more feeding bouts) and for longer durations than were pigs in water-court pens. Pigs in water-court pens spent significantly less time eating and had fewer eating bouts than did pigs in conventional pens during observational periods. Thus, pigs in water-court pens had fewer eating bouts and shorter durations of eating than did pigs in other auto-sort groups. Floor layout also significantly influenced number of pigs engaged in eating at one time; with larger group sizes and more eating bouts being observed among pigs in the food-court and fast-lane than water-pen. Number of pigs engaged in drinking was significantly influenced by auto-sort layout. Pigs in the food-court ate in larger groups, but drank in smaller groups. These behavioral patterns were most likely dictated by the placement of feeders and waterers within each system. In the food-court, the waterers that were placed between feeders were limited, so majority of waterers were located on outer edge of "food-area" pen which influenced not only eat-drink sequences but aggressive behaviors as well.

The frequency of **aggressive behaviors** was greater among pigs in conventional pens than among those pigs in either fast-lane or water-court pens – less aggression was observed among pigs in these 2 auto-sort layouts. However, pigs in food-court performed significantly more ear bites and aggressive behaviors than did pigs in the other auto-sort layouts. We hypothesize that as resources become limiting, aggressive behavior increases – hence due to the limited access pigs had to resources this altered the eat-drink sequence. In the food-court, as duration of eating increased, waterers within the "food-area" became limiting, thus resulting in an increase in competition for the waterers directly beside the feeder holes. Essentially pigs won't leave feeder-hole to seek out water (located on outer edges of food-pen area) because once a pig leaves feeder-hole another pig immediately moves in. We observed an increase in aggressive behavior in the food-area only among pigs in the food-court pens. The magnitude and duration of these aggressive encounters significantly increased during the late-finishing phase. We hypothesize that they become limiting because there is a change in frequency and duration in eating and drinking bouts – as pigs get larger, they eat less often, but duration of each meal is longer.

These data indicate that the social patterns of pigs within these large groups are affected by pen layout. Overall activity is much greater among pigs in food-court and fast-lane pens compared with pigs in conventional pens; however, pigs in conventional pens are more active than are pigs in water-court pens. This inactivity may be indicative of a lack of motivation of the pigs to move within the system other than to eat or drink. Thus, pigs in this system eat and then seek water in the water-pen area and then immediately ly down until next feeding bout *or they are pushed out. Moreover, these results indicate that feeder and waterer design and placement within an auto-sort layout alters feeding, drinking, lying and aggressive behaviors and more importantly alter sequences of eat-drink. For example, in the food-court as pigs become bigger, the duration of feeding bouts increases (especially during late finishing), thus water availability becomes limiting, thus leading to an increase in aggression around the waterers located closest to a feeder-hole. Pigs had limited access to waterers that were located next to a feeder-hole, thus the majority of pigs had to seek cup waterers (which were located on the outer edge of the food pen area) which results in loosing feeder-hole. By limiting resources, aggression increases and alters normal eat-drink sequences. Also, this aggression may contribute to the increase in lameness that was observed during loading and it may actually slow growth down as well.*

Behavioral data collected during **training** indicate, regardless of treatment, pigs learn to use the scale (habituate) quickly. By d2 of training, the majority of pigs "learned" to use the scale (both entering and exiting). Pigs in the water-court layout tended to show a greater "fear-type" response during the training process, this response was less apparent among the other auto-sort groups. This observation was based on the amount of time it took pigs to enter and exit the scale; with pigs in water-court taking significantly more time. Moreover, pigs in water-court tended to use the equipment to perform oral-nasal-facial behaviors (undesirable behaviors) and used the scale as a lying area (or safe haven) during this period which may be indicative of a "fear-type" response as well. However, these responses and differences could be attributed to insufficient training or malfunctioning equipment. For example, if equipment malfunctions it tends to lead to undesirable behaviors and inappropriate use of equipment. Unfortunately, this did occur in the water-court treatment during the first replicate. Thus, proper training and properly functioning equipment are an absolute must.

Behavioral data collected during **loading** indicate that pigs from auto-sort layouts load significantly faster than did pigs from large conventional pens. Pigs from conventional pens **vocalize** more often when removed from pens and during handling compared with pigs from auto-sort pens. Often vocalization is indicative of "fear-response"; pigs from conventional pens were observed rearing more often than were pigs from either the fast-lane or food-court. As for **handling ease,** pigs from the food-court were significantly less difficult to handle while loading onto the truck than were pigs from conventional pens. But, there was only a trend for pigs from the fast-lane and water-court pens to be less difficult to handle during loading compared with conventionally-kept pigs. Upon removal from the pens, pigs from the fast-lane handled significantly better than did pigs from the food-court while exiting the pens, while pigs from water-court handled better than did pigs from the food-court upon removal from pens. This is most likely due to a design flaw in the layout. During the **actual loading** process, pigs from conventional pens took significantly more time to load than did any of the pigs from auto-sort pens. Among the pigs from the auto-sort pens, pigs from the fast-lane loaded faster than did pigs from water-court pens. Neither location of pen or truck affected loading time. **Lameness** was observed more often in pigs from food-court pens than conventional pens, this could be an affect of pen location. More pigs were observed to be lame coming from the food-court than the conventional pen in which pigs from food-court had to walk greater distance. However, during the first replicate, more pigs were pre-marketed from the fast-lane than any other treatment group due to "leg problems". **Prod use** was also required more often when removing pigs from pens and during loading for pigs in the conventional pens than for pigs from any of the auto-sort pens.

Regardless of auto-sort layout, properly trained pigs learn to use "the system" relatively quickly without developing undesirable behaviors. However, if the system malfunctions or pigs are not trained properly this may lead to undesirable behaviors and use of the equipment or system. Moreover, pigs from auto-sort pens (more specifically food-court) load faster and handle better than did pigs from a large conventional pen.

2. Routine performance parameters, handling, and carcass-quality scores were evaluated.

Performance data results (**not statistically analyzed)** indicate that pigs from conventional pens had better **ADG** gain than did pigs from any of the auto-sort layouts. However, among the auto-sort layouts, pigs in both the food-court and water-court had greater ADG than did pigs from fast-lane. Pigs from the food-court pens had better **feed conversion ratio, feed cost/pig, and feed cost/lb of feed** than did pigs from all other treatment groups including the conventional pens. But, **days-to-market** were less for pigs in conventional pens, than for pigs in any of the auto-sort pens. Among the auto-sort treatments, days-to-market were less for pigs from the food-court pens. However, more pigs from the auto-sort treatments were pre-marketed compared to pigs from conventional pens. At 10- and 3-weeks prior to first sort, the average body weight for pigs in the food-court was greater than all other auto-sort treatments, but at 1-week prior to sort, pigs from the fast-lane were as heavy as pigs from the food-court. But, pigs in water-court pens still lagged in average body weight compared to the other 2 auto-sort treatments. As for **sort-loss**, there was less sort-loss among pigs from food-court pens than any of the other auto-sort treatments. **Loin, ham, and belly weights** were greater among pigs from a water-court layout than either conventional or food-court (first sort and Trial 1 only). **Hot carcass weight** was lowest among pigs that were kept in food-court compare to all other treatment groups (Trial 1 and 2). But in Trial 3, **hot carcass weight** was greater among pigs from the food-court than the fast-lane. **Mortality rate** was higher among pigs from the fast-lane than all other treatments. In fact, mortality rate was higher among all auto-sort treatments compared to conventional pigs.

In this study, auto-sort appears to have an impact on performance and carcass characteristics. Overall pigs from the food-court pens were more efficient based on better feed conversion, feed cost/pig and cost/lb of feed. However, days-to-market were less for pigs from conventional pens than for pigs from auto-sort pens.

***We do have individual body weight data but the excel spread sheets are enormous and will take some time to analyze. Once this task is completed we will share results with NPB.**

3. *Physiologic analyses will be employed to further determine (in appropriate sub-samples of pigs) any impacts of several production systems on pig performance, carcass quality, and overall pig welfare.*

Physiological data indicate that treatment had an effect on the way pigs coped/adapted to their environment. **Physiological data** indicated that pigs from the fast-lane pens responded differently to handling/transportation stressors than did pigs from other treatment groups. **Leukocyte populations** were significantly decreased in pigs from fast-lane pens post handling/transportation whereas, those pigs in conventional pens had higher leukocytes pre- and post-stress. Thus, implying that these stressors had an effect on both pigs in the fast-lane and conventional pens. Stress can suppress and/or enhance the immune system. However, a classical acute stress response is an increase in the **neutrophil-to-lymphocyte ratio**, these result indicate that prior to loading/transportation, pigs in all of the auto-sort treatments had normal levels of lymphocytes, however after stress there was a dramatic shift in the neutrophil-to-lymphocyte ratio (classical stress response); with the greatest magnitude of change occurring in pigs from the conventional pens. This shift in leukocyte population indicates that handling/transportation stressors are perceived as stressful regardless of treatment. However, handling/transportation was more stressful for pigs from conventional pens than from auto-sort pens. Among auto-sort treatments, pigs from the water-court pens had the greatest "stress response" compared with pigs from food-court and fast-lane pens. **Plasma cortisol** (an indicator of acute stress) was greater among pigs from conventional pens prior to loading/transportation, which may imply that these pigs may perceive their environment and/or handling as a stressor. Cortisol levels were greater post-stress among all treatments; among auto-sort treatments, the food-court pigs had the greatest increase in cortisol post-stress than did pigs in the 2 auto-sort treatments. Another measure of stress used was **insulin-like growth factor-1 (IGF-1)**. Pigs from the food-court pens had greater levels of unbound IGF-1 prior to stress, than did pigs from all other treatment groups. IGF-1 binds to a binding protein which influences growth in animals, thus these data imply that it is possible that pigs in the food-court pens may have a greater potential for increased growth rate. We do speculate that these pigs do but the system has to be optimized further to take advantage of this possibility.

These data indicate that auto-sort may have an impact on the magnitude of the stress response that is initiated in response to handling and transportation. It seems that pigs from auto-sort layouts may have a "diminished stress response" compared with those from large conventional pens.

Experiment 2: Food Court (South), Food Court (North), Conventional Small Pen (35-40 pigs per pen; North), Conventional Large Pen (300 pigs per pen; South). *This experiment was designed based on data collected in Experiment 1. Also, there was a PRRS outbreak.

NOTE: all data presented are significant at P < 0.05, unless specifically stated, no statistical analysis.

1. *To further assess the effects of a food-court layout on training and loading processes compared to both a small and large pen conventional wean-to-finish.*

2. *To assess the overall well-being of pigs kept in a food-court layout compared to two different conventional pens (large and small).*

Unfortunately, from a scientific standpoint, these data should be viewed with caution. This farm had a major PRRS outbreak and PRRS went through the entire farm at different times (actually it was affected by floor-layout). Despite the PRRS outbreak there were significant differences between treatments during **handling and transportation.** Specifically, pigs from small conventional pens **vocalized** more during removal from pens than did those from large conventional pens or food-court pens. Pigs from large conventional pens **vocalized** more during loading than did pigs from small conventional pens and pigs from food-court. During loading, pigs from small conventional pens significantly **reared** more than did pigs from large conventional pens during loading. Pigs from small conventional pens also **reared** more than did pigs from food-court pens during loading. Pigs from large conventional pens tended to be lamer than were pigs from food-court pens. But, pigs from small conventional pens tended to be lamer than pigs from large conventional pens. Pigs from small pens required more **prod use** during loading than did pigs from large conventional pens. Also, conventional pigs regardless of group size required more **prod use** during loading than did pigs from food-court pens. Food court pigs were **less difficult to handle** upon removal from pen than large and small conventional pens. Pigs from small conventional pens were most difficult to load onto truck. Large were more difficult than food-court. Pigs from small conventional pens took the most **time to load**.

Physiological data indicate that pigs from large conventional pens had the greatest **total leukocyte numbers** pre- and post-transportation compared to all treatment groups. Post-transportation, pigs from small conventional pens had significantly greater **total leukocyte numbers** than did food-court pigs. Pre-transportation, pigs from large conventional pens have greater **neutrophil-to-lymphocyte** ratio than did pigs from food-court. But, pigs from small conventional pens have greater ratio than did pigs from either food-court or large conventional pens post-transportation. Pigs from large conventional pens had greater ratio post-transportation than did pigs from food-court pens. Pigs from large conventional had significantly greater **cortisol** than did pigs from small conventional pens prior to transportation. Pigs from large pens had significantly greater **cortisol** pre and post-transportation than did pigs from food-court pens. Also, pigs from small conventional pens had greater cortisol post-transportation than do pigs from food-court pens.

Experiment 3: Food-court layouts with two feeder types and "resource" placements: (1) wet/dry feeders, new placement; (2)wet/dry feeders, original placement; (3) dry feeders, new placement; and (4) dry feeders, original placement.

"Original (Old)" placement = 8 feeders w/ 12 waterers; feeders placed in straight line
"New" placement = 8 feeders w/ 12 waterers; feeders "staggered" and w/ dry feeders increased access to waterers by feeders.

NOTE: all data presented are significant at P < 0.05, unless specifically stated, no statistical analysis.

1. *To determine if feeder type and resource placement would impact behavioral and productivity measures in wean-to-finish pigs.*

2. *To further attempt to optimize a food-court auto-sort layout by altering two specific components of the system (feeder type and placement of resources) that may improve animal well-being.*

Impact of feeder type and resource placement on training and handling ease

Feeder type or placement of resources did not impact **training**. On day 1 of training, regardless of treatment, all pigs were observed engaged in longer bouts of **aggression**, but pigs in treatment 4 *(original food-court design == dry feeders and original feeder placement)* had longer bouts of aggression on day 1 than all other treatment groups. Regardless of treatment, all pigs took longer to **enter and exit scale** on day 1 and 2 with time decreasing on the proceeding days. All pigs **hesitated** longer to enter scale on day 1 and 2 than proceeding days. On days 1 and 2 of training all pigs were observed performing **oral-nasal-facial behaviors** with frequency and duration decreasing on proceeding days. **Handling/Loading:** Feeder type had an impact on frequency of **vocalizations** upon removal from the pen and during loading. Pigs from pens with dry feeders (treatments 3 and 4) vocalized more frequently than did pigs from pens with wet/dry feeders (treatments 1 and 2), regardless of placement. Feeder type had an impact on **prod use**; pigs from pens with dry feeders required more prod use during handling/loading than did pigs from pens with wet-dry feeders.

All treatments habituated to using the scales within first 2 days of training, regardless of feeder type or placement. Thus, feeder type or placement did not impact the "learning curve" or training ability of the pigs. However, feeder type did influence fear-response and handling ease, with more vocalizations and prod use being observed among pigs from pens with dry feeders.

Impact of feeder type and placement on pig well-being

Pigs in all treatments had significantly greater total **leukocyte numbers** from pre- to post-transportation. However, baseline leukocyte numbers (prior to transportation) were greatest among pigs in treatment 4 (dry feeders, original layout). Also, pigs from treatment 3 (dry feeder; new placement) had greater leukocyte numbers than did pigs from treatments 1 and 2 (both w/ wet/feeders). Thus, feeder type impacted leukocyte numbers. Lymphocytes were significantly decreased among all pigs pre- and post-transportation regardless of treatment. Feeder placement had an effect on **immature neutrophils**, such that pigs in the pens with original feeder placement had less immature neutrophils than did pigs in pens with new feeder placement. Post-transportation treatments 2 and 4 (original feeder placement) had greater percentage of immature neutrophils than did pigs from pens with new feeder placement. Overall immature neutrophils increased from pre- to post-transportation regardless of treatment. Pigs from pens with wet/dry feeders and new placement (treatment 1) had the greatest percentages of **mature neutrophils** prior to transportation. Feeder placement impacted percentage of mature neutrophils; with pigs from pens with new resource placement had greater percentage than pigs from pens with original placement. All treatments had increased neutrophils from pre- to post-transportation, with the exception of pigs from treatment 4. All pigs had a significant increase in **neutrophil-to-lymphocyte ratio** from pre- to post-transportation. Feeder placement impacted **cortisol** levels, post-transportation; with pigs from pens with original feeder placement having greater cortisol than did pigs from pens with new feeder placement. In all pigs, cortisol increased from pre- to post-transportation.

These data indicate that feeder type and placement of resources had an impact on physiological responses of the wean-to-finish pigs to handling and transportation. Pigs from pens with new resource placement had less of a cortisol response to transportation than did those pigs from pens with original placement. Thus, depending on the feeder-type or placement of resources these factors may influence stress responses of pigs to handling and transportation stressors.

Impact of feeder type and placement on pig performance (no statistical analysis)

Pig performance was impacted by feeder type and placement of feeders/waterers. **Average live weight** (weight at sort) was greatest for pigs from treatment 4 (dry feeders; original placement). Regardless of treatment, all pigs had similar **ADG**, but ADG was less among pigs from treatment 2 (wet/dry feeders; original placement). **Feed**

conversion was greatest in pigs from treatment 1 (wet/dry feeders; new placement), but worst for pigs from treatment 2 (wet/dry feeder; original placement). **Feed cost per pig** was similar among pigs from treatments 1, 2, and 3 (dry feeders; new placement), but feed cost per pig was greatest for pigs from treatment 4. **Pounds of feed per pig** was least for pigs from treatment 2 but greatest for pigs from treatment 4. **Cost per cwt** was similar with the least cost being found among treatment 4. Pigs from treatment 4 had heaviest **hot carcass weights** whereas hot carcass weight was similar for all other treatment groups. Percentage of **lean** was similar among all treatment groups. Pigs from treatment 2 had least **backfat** thickness. Dressing percentage was fairly similar among all treatment groups. We hypothesize that in this particular "food-court" layout those pigs in pens with wet/dry feeders would have greater improvement in performance than those pigs in pens with dry-feeders; however, it took the manager about month to really learn how to correctly use these feeders.

These results imply no differences in performance based on ADG or feed efficiency. But, we do believe that pigs fed with wet/dry feeders would have improved performance because these animals actually lagged in growth and then recovered. We believe this was due to manager having to learn how to use these feeders to reap the full benefits from this system. Overall, pigs in treatment 2 (wet/dry feeders; original placement) was most efficient per se. Pigs in treatment 1 (wet/dry feeders; new placement) had greatest rate of gain but least efficient. There were "positive and negative" attributes associated with all treatments thus, implying that feeder type and resource placement does affect performance but still hasn't been optimized. Carcass results indicate that dry feeders produce a better product; however this may be due to the producer's choice to sell at different weights.

VIII. Discussion (Summary):

Overall Summary (Experiment 1).

These data provide scientific evidence that regardless of auto-sort layout pigs learn rather quickly how to use these systems. Within 5 days of training, duration of time to enter and exit scales were significantly reduced in all auto-sort layouts. On average it takes pigs 2 days to "learn to use system". Based on behavioral data, auto-sort layouts may reduce stress during handling and loading/transportation processes; with one exception, pigs from food-court pens were more difficult to remove from pens during loading but this was mostly likely due to a flaw in the layout of the system. The design flaw was created by feeder placement; specifically the placement of the feeders enabled the pigs to avoid handlers upon removal from pens. Once pigs were out of the pens the handled and loaded better than most of the other treatment groups. In some situations, vocalization and rearing behavior can be indicators of stress. If in this study, vocalizations and rearing behaviors are indicators of stress, we hypothesize that pigs kept in large conventional pens are more "stressed" during handling and loading/transportation processes than are pigs from various auto-sort layouts. Data from this study support the notion that pigs from auto-sorts are much easier to handle and require less prod use than do pigs from large conventional pens. It also takes less time to load pigs that come from auto-sort pens.

	Treatment		
Behaviors	**Food Court**	**Fast Lane**	**Water Court**
Fear response to scale	+	++	-
Ability to use scale	+	++	+
Habituation to scale	++	++	++

++ indicates significantly better; + indicates good; - indicates not as good/bad

	Treatment			
Loading behaviors	**Food Court**	**Fast Lane**	**Water Court**	**Conventional**
Prod use	+	+	+	-
Lameness	-	+	+	+
Fear response	+	+	+	-
Handling Ease	+	+	+	-
Loading time	++	++	+	-

++ indicates significantly better; + indicates good; - indicates not as good/bad

Auto-sort layout and location of resources affects various maintenance behaviors (e.g., eating, drinking, lying) and aggressive interactions. Based on the layout of the food-court, pigs tended to walk, stand, and ly in larger groups (greater than 10) throughout the entire wean-to-finish phase, while pigs in large conventional pens typically performed various behaviors in smaller groups (1-5 pigs). These differences in behavioral patterns indicate that auto-sort layout influences the social patterns as well as the typical maintenance patterns (e.g., eat-drink sequence) of pigs. Overall, pigs in the water-court layout were least active and had less eating bouts during the observational period compared with all other treatment groups. Based on eating behavior, auto-sort layout influences group size, and the frequencies and durations of eating. Frequency of agonistic behavior was greatest among the pigs in the large conventional pens. Among the auto-sort treatments, the greatest level of aggression was observed among the pigs in the food-court pens. In fact, it appears that aggression was reduced among pigs in the fast-lane and water-court pens. However, it is hypothesized based on these data that aggression was increased within the food-court layout based on placement of resources and restriction of access to resources. Our data support that the aggression encounters occurred within the food-area pen around waterers and feeders. This really was apparent in the late finishing-phase when eating bouts increased significantly in duration and waterers became limiting per se. Waterers were not limited throughout the system, only the waterers right next to feeder hole became limiting. The feeder and waterer layout within the "food-court" area resulted in increased aggression because pigs had to leave feeder-hole to access waterers on the outer-edges of the pens, thus leading to not enough waterers dispersed close to feeder holes or in the feeding pen.

	Treatment			
Wean-to-finish behaviors	**Food Court**	**Fast Lane**	**Water Court**	**Conventional**
Activity	-	+	+	-
Eating	++	+	-	-
Drinking	+	+	-	+
Aggression	-	+	+	-

++ indicates significantly better; + indicates good; - indicates not as good/bad

Physiological data such as cortisol and shifts in various leukocytes (both classical signs of acute stress) indicate that pigs within these different environments perceive stress differently. Based on cortisol responses and shifts in various leukocyte populations, we hypothesize that pigs kept in large conventional pens may be more "stressed" compared with pigs in auto-sort pens. Pigs in large conventional pens had greater numbers of leukocytes pre-handling/transportation than did pigs from the various auto-sort layouts. Also, pigs from large conventional pens had a greater magnitude of change in the neutrophil-to-lymphocyte ratio (classical indicator of acute stress) post-transportation compared with all auto-sort treatments. However, all pigs had a shift in their neutrophil-to-lymphocyte post-transportation, but not as dramatic as pigs from large conventional pens. Plasma cortisol increased among all pigs after transportation. Among auto-sort pigs, pigs from the food-court pens had greater insulin-growth-factor 1 than did all other treatment groups, thus implying that there was more IGF-1 available to bind the IGF receptor, implying greater potential for growth.

	Treatment			
Physiology	**Food Court**	**Fast Lane**	**Water Court**	**Conventional**
Leukocyte response	+	++	-	-
Cortisol stress response	+	++	++	-
IGF-1	++	+	+	+

++ indicates significantly better; + indicates good; - indicates not as good/bad

Rate of gain was greatest in pigs from large conventional pens, but pigs from food-court pens had the best feed efficiency based on feed conversion ratio, feed cost/lb and feed cost/pig. Days-to-market was less among pigs from conventional pens, but among pigs from auto-sort layouts, pigs kept in food-court pens had better rate of gain than did those pigs from water-court pens. Pigs in the food-court were heavier from 10-weeks to 1-week prior to sorting compared to pigs from water-court. By 1-wk prior to sorting, the fast-lane pigs surpassed the food-court pigs, but water-court pigs still lagged behind both treatments. We speculate that the slow-down among the food-court pigs may be due to "limiting resources" and substantial increase in aggression. Access to waterers is restricted during the late-finishing phase and this leads to an increase in aggression. This increase in aggression in conjunction with altering eat-drink sequence may have a negative effect on rate of gain. These data also indicate that the least sort-loss was recorded in the pigs from the food-court. In fact, the sort-loss recorded in the food-court was due to "light" pigs at the packing plant. This sort-loss could be due to an inaccurate recording of pig weight – if there isn't enough pressure on the scale doors, two pigs may enter at the same time and the weight recorded is for both pigs. In this study, the fast-lane treatment resulted in greater sort loss, due mainly to "too heavy" of pigs. This may be due to design flaw (lack of motivation for pigs to move through system) in conjunction with inadequate training or not pushing pigs through the system. Also, fast-lane recorded the highest mortality rate and higher number of pre-marketed pigs; we hypothesize that the large number of one-way gates may partially contribute to this problem. Results from the carcass measures from trial one only, indicate that pigs in the water-court had greater loin, belly, and ham weights. This may be partially explained by the fact that pigs in the water-court were least active, thus expanding less energy. Hot carcass weight was variable throughout all 3 trials. The pigs from the food-court has the lowest hot carcass weight during trials 1 and w but the heaviest hot carcass weights during trial 3.

Performance measures	Treatment			
	Food Court	**Fast Lane**	**Water Court**	**Conventional**
ADG (lb.)	1.39	1.36	1.39	**1.45**
Lb. Feed: lb. Gain	**2.53**	2.78	2.68	2.60
Feed cost / pig ($)	**42.40**	47.30	45.30	45.20
Feed cost / lb. ($)	**0.176**	0.194	0.185	0.183
Days to market	184	190	186	**177**
# pre-market pigs	28	28.3	31	**19.3**
Sort loss ($)	**173.41**	*396.54*	180.19	252.53
Loin (lb.)	42.6	43.0	**48.0**	42.4
Ham (lb.)	52.6	53.2	**53.7**	52.8
Belly (lb.)	25.5	25.5	**26.2**	25.3
% Lean	**55.3**	**55.1**	54.6	54.5
Hot Carcass weight **trial 1**	206.4	212.1	**213.9**	212.9
Hot Carcass weight **trial 2**	208.4	213.3	212	**215.5**
Hot Carcass weight **trial 3**	**217.8**	213.6	215.3	215.7

Red/bold indicates the best compared to all treatments

Overall Summary (Experiment 2)

Once again pigs trained rather quickly to using the scales within the food-court pens. Pigs initially showed a fear response during early training but diminished over-time. Once again, vocalization results indicate that when removed from the pen, pigs in conventional pens (both large and small) vocalize more than do pigs from auto-sort pens. Pigs from small conventional pens reared more often, required more prod use, more difficult to handle and took more time to load. Pigs in large conventional pens handled and load better than did pigs from small conventional pens, but pigs from food-court handle better and load faster than do pigs from conventional pens.

	Treatment		
Loading behaviors	**Food-Court**	**Sm. Pen Conv.**	**Lg. Pen Conv.**
Prod use	++	-	+
Lameness	+	-	-
Fear response	+	-	+
Handling Ease	++	-	-
Loading time	+	-	+

++ indicates significantly better; + indicates good; - indicates not as good/bad

Once again (as seen in experiment 1), regardless of treatment, there was a shift in the leukocyte populations in all pigs following handling/transportation. However, the magnitude of change was less prominent among pigs in the food-court pens compared to the pigs from the conventional pens. Pigs in the food-court pens had lower cortisol pre-handling/transportation than did pigs in the conventional pens, thus indicating that may not perceive the environment and/or handling as 'stressful' as pigs in conventional pens. Cortisol did increase post-transportation but not to the magnitude of the conventional pigs. IGF-1 decreased after stressors in all treatment groups except in pigs from the small conventional pens; with it increasing after transportation.

	Treatment		
Physiology	**Food Court**	**Sm. Pen Conv.**	**Lg. Pen Conv.**
Leukocyte response	++	-	-
Cortisol stress response	++	-	-

++ indicates significantly better; + indicates good; - indicates not as good/bad

Overall Summary (Experiment 3)

Pigs in all treatments habituated within the first two days or sooner to using the equipment within the system. Feeder design or placement did not impact the learning curve of these pigs to the auto-sort system. Motivation of the pigs to use the scales was not influenced by feeder type or feeder placement.

	Treatment			
Training behaviors	**TRT 1**	**TRT2**	**TRT3**	**TRT4**
Fear response to scale	+	-	-	+
Learning ability to scale	++	+	+	++
Habituation to scale	++	++	++	++

++ indicates significantly better; + indicates good; - indicates not as good/bad
TRT 1 = wet/dry feeder; new placement; TRT 2 = wet/dry feeder, old placement; TRT 3 = dry feeder, new placement; TRT 4 = dry feeder, old placement;

Feeder type influenced fear response based on vocalization. Pigs from pens with dry feeders regardless of placement, vocalized more during removal from pens and the actual loading process. Pigs from pens with dry feeders and new feeder placement require more prodding when removing from pen, implying that other factors may contribute to removal from pens other than feeder type and feeder placement. Pigs from pens with wet/dry feeders vocalized less and required less prodding, thus implying that wet/dry feeders may impact animal handling during loading.

	Treatment			
Loading behaviors	**TRT1**	**TRT2**	**TRT3**	**TRT4**
Prod use	++	++	+	+
Fear response	++	++	+	+

++ indicates significantly better; + indicates good; - indicates not as good/bad
TRT 1 = wet/dry feeder; new placement; TRT 2 = wet/dry feeder, old placement; TRT 3 = dry feeder, new placement; TRT 4 = dry feeder, old placement;

Although all pigs had an increase in leukocyte numbers pre- to post-transportation, feeder type did influence this response. Pigs from pens with dry feeders had greater leukocyte numbers than did pigs from pens with wet/dry feeders. Feeder placement had an effect on a specific population of leukocytes – neutrophils. Pigs from pens with original feeder placement had less immature and mature neutrophils than did pigs from pens with new feeder placement. An acute stress response occurred in all pigs regardless of treatment as indicative of an increase in the neutrophil-to-lymphocyte ratio. These immune data imply that feeder type and or location may influence the immune system. Feeder placement impacted cortisol levels, post-transportation; pigs from pens with new placement had less of a cortisol response to transportation. However, all treatments did show a stress response to the loading/transportation. There was a tendency for pigs from new feeder placement pens to have a lower cortisol response to stress, thus indicating a better adaptability to transportation stress. It is possible that feeder placement eased the removal of pigs from pens.

Physiology	TRT1	Treatment TRT2	TRT3	TRT4
Leukocyte response	++	++	+	+
Cortisol stress response	++	+	++	+

++ indicates significantly better; **+** indicates good; **-** indicates not as good/bad
TRT 1 = wet/dry feeder; new placement; TRT 2 = wet/dry feeder, old placement; TRT 3 = dry feeder, new placement; TRT 4 = dry feeder, old placement;

Results from the performance data indicate that there is no consistent impact of feeder type or arrangement on pig ADG or feed efficiency. But, overall pigs from treatment 1 had the best rate of gain, but not the most efficient. Each treatment group had positive and negative attributes when comparing performance and carcass measures. Implying that feeder type and placement are important components, the food-court has still not been optimized.

***NOTE: This study was only replicated once and there was a "learning curve" associated with managing the wet/dry feeders for manger.**

Performance measures	TRT1	Treatment TRT2	TRT3	TRT4
ADG (lb.)	**1.5**	1.4	1.4	1.4
lb. Feed: lb. Gain	2.8	**2.7**	2.7	2.8
Feed cost / pig ($)	66.2	**65.9**	66.0	68.5
lbs. of feed / pig	615.5	**608.8**	617.0	635.4
Cost / carcass wt.	30.6	29.0	**28.9**	30.1
Avg. Live wt.	230.0	239.4	239.4	**243.2**
Hot Carcass wt.	176.0	177.6	177.6	**184.5**
Back fat (inches)	0.72	**0.66**	0.70	0.72
Lean (%)	53.6	**54.7**	54.4	53.9
Dressing (%)	76.5	76.7	77.3	75.8

Red/bold indicates the best compared to all treatments.
TRT 1 = wet/dry feeder; new placement; TRT 2 = wet/dry feeder, old placement;
TRT 3 = dry feeder, new placement; TRT 4 = dry feeder, old placement;