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Influence of rearing space on the behavior, performance, carcass and meat quality of pigs

VIKTORAS LIORANČAS, BRONIUS BAKUTIS, GRAŽINA JANUŠKEVIČIENĖ

Department of Food Safety and Animal Hygiene, Lithuanian Veterinary Academy Tilžės 18, 47181 Kaunas, Lithuania

Liorančas V., Bakutis B., Januškevičienė G.

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Summary

The objective of the study was to assess the effects of rearing space on growing pig's behavior, performance and meat quality. 120 pigs were reared to slaughter at 14 weeks in restricted or spacious conditions. The restricted conditions were defined as intensive production system (slatted floors and minimum recommended space allowances) and the spacious conditions incorporated extra space (one of the main factors in organic animal husbandry). Rearing space influenced pig behavior. Observations showed that spacious conditions reduced the time spent inactively and time spent in harmful social and aggressive behavior. Growth rates were also higher for pigs in spacious pens ($p < 0.001$) and this led to heavier carcass weights (n.s.). Pigs from spacious conditions also had thicker backs (n.s.). The enrichment of conditions had a small but significant effect on meat quality. Pork from pigs reared in restricted conditions had lower pH 24 post mortem ($p < 0.001$), was less tender, and had poorer water holding capacity than pork from pigs reared in spacious pens (n.s.).

Keywords: pigs behavior, performance, carcass, meat quality

In recent years consumers have become interested on the way the food is produced. Intensification of farming has been perceived as a negative development. It should be pointed out that variations are observed in the emphasis of consumers regarding the welfare of animals, particulary when they buy meat. Some do not consider welfare at all; whereas others have certain requirements that vary according to their particular perception as to what is good welfare (2). It is generally accepted that enrichment of rearing conditions substantially improves the welfare of growing pigs (29). In barren rearing conditions, pigs tend to redirect exploratory behavior towards pen mates, and this can lead to persistent aggression and cannibalism (4). In addition, high levels of pen mate in less spacious conditions have a negative effect on the productivity of pigs due to disturbances in feeding patterns (23). There are also lower growth rates of pigs in small area of pen than in enriched conditions due to increased energy requirements for heat maintenance in the absence of substrates (18). Growth rates of pigs are affected by elevations of the stress hormones. The responses to stress factors results in release of neurotransmitters in the brain, which stimulates the nervous system and releases stress hormones into the blood, which might stimulate muscle metabolism negatively in relation to subsequent pork quality (22). Meat quality may also be affected by rearing conditions. Poor on farm handling increases pig susceptibility to preslaughter stress (8). Pale, soft and exudative (PSE) meat can be influenced by levels of preslaughter stress (14).

Free range and organically reared pigs have been reported of having increased lean meat yields (9) and greater wholesale carcass value, due to heavier butts, loins and hams compared to pork of pigs from a confinement system (24), however, they also had higher amounts of intramuscular fat (26). It was shown that extensive housing compared to intensive (slatted floors and minimum recommended space allowances) resulted in pork with improved quality as shown by decreased water loss during cooking (3).

The objective of the present study was to assess the effects of rearing space on pig growing, their behavior, performance and meat quality.

Material and methods

A total of 120 crossbred female and castrated male pigs (Danish Landrace × Danish Yorkshire × Danish Duroc) were raised under experimental conditions from October to January at the commercial pig breeding station. The animals were allocated in two groups when they were approximately 100 days old. Animals were kept indoors in 10 pens with slatted floors. 60 pigs (control group) were raised in pens with minimum recommended space allowances (0,5 m^2/per pig) and other 60 (experimental group) – in respectively 1,2 m^2/pig. All pigs used in this study had been tested as free of the detrimental alleles of both the Halothane and RN genes.

Both pig pens at all stages had a day/night cycle, with full lighting between 08^{00} and 17^{00} hours. The temperature was maintained at 15-20°C and relative humidity of the air was 65-75%. Water was available all the time. Animals were fed with conventional feed mixture *ad libitum* 7 times per day using sensory wet feed feeders. At the beginning of the experiment the average weight of pigs was 39 kg each. Pigs were slaughtered at the 97^{th} day of fattening when they gained the average weight of 114 kg. Pigs were transported to a local commercial slaughter house and kept in lairage for 2 h with their original pen mates before being stunned and slaughtered.

In total, 20 carcasses were subjected to carcass and technological meat quality studies; 10 of control pigs and 10 of experimental pigs. Selection of trial animals was made after weighing all the animals and choosing those which were leastwise outlying from the medium weights. Carcasses were weighed and then lean meat percentage was determined with an optical probe Fat'o Meater. After that, carcasses were chilled at 2°C. Features of meat quality were determined in chilling room and in the laboratory. pH of Longisimus dorsi muscle was measured 45 min (pH_1) and 24 h *post mortem* (pH_2) using an electrode probe connected to a portable IQ 150 PH meter (IQ Scientific Instruments). were made at 5 cm depth, in the region of the last riba t the left half of the carcass respectively. All other meat quality determinations were carried out on samples of m. L. dorsi. Muscle was disected from the carcass 24 h *post mortem* from the left dorsal area of the carcass in the region of the last rib.

Water holding capacity was determined as filter paper wetness. Meat colour was measured using a Minolta Chroma Meter CR-410 (Osaka, Japan) with a D_{65} light source calibrated against a white tile. The *L*, a* and b** of meat colour were recorded on the middle of each sample. Shear force was determined using Warner – Bratzler method. Samples were aged for two days and then stored in –80°C until analysis. The muscle samples were then thawed at 4°C and cooked without cover in boiling water until internal temperature of 72°C was reached. Three 13 mm cores, cut along the fiber axis, were taken from each sample, and three recordings were made on each core. The mean value of nine recordings was used in the calculations of shear force.

Behavior studies for both treatments were carried out by help of camcorder. Animals were recorded in fattening period continuously (24 hours per day) prior of month till slaughtering using observation camera and a recorder. Revising the tape, two focal animals in each pen were chosen to count the mutual interactions. The main behavior components were recorded (ingestion (feed ingestion) time, nosing each other, biting each other, fight, fixtures explore, resting (inactive) and other) and percentage was counted for each.

No deaths of pigs were registered during this study.

Results and disscusion

Results of the behavior studies are given in tab. 1.

Pigs in pens with rearing space of 1,2 m^2/pig showed great exploring of fixtures (28,1%), more than a quarter of their time, respectively, while pigs in 0,5 m^2 space for each only 19,8% of the time. Pigs in smaller area pens spent less time for resting (21,7%), while experimental animals had more time for that and spent 25,3% of the time. So, pigs in enriched conditions spent less time in social harmful behavior such as nosing, biting each other or fighting. Respectively, pigs in small pens spent more time more time involved in those types of social behavior.

Tab. 1. Percentage of observation time spent performing different behaviors of pigs in minimum rearing space allowances (0,5 m^2/per pig) and enriched conditions (1,2 m^2/pig)

Behavior	Rearing conditions	
	0,5 m^2/pig	1,2 m^2/pig
Ingestion time	12,9	14,3
Nosing each other	13,2	10,6
Biting each other	8,2	1,8
Fight	6,2	0,5
Fixtures explore	19,8	28,1
Resting (inactive)	21,7	25,3
Other	18,0	19,4

Analyzing recordings, it was noticed that pigs had a stereotypic behavior in restricted conditions (2 cases), while pigs in enriched conditions did not make any of the stereotypical moves.

Tab. 2. Average performance of pigs

Parameter	Rearing conditions	
	0,5 m^2/pig	1,2 m^2/pig
Weight at the beginning of the rearing, (kg) experiment, (kg)	39,0 ± 0,31	39,5 ± 0,28
Weight at slaughter, (kg)	113,0 ± 0,81***	117,9 ± 0,68***
Growth rate, (g/day)	760,0 ± 0,74***	800,0 ± 0,80***
Dressing percentage, %	73,18 ± 2,08*	79,74 ± 2,25*
Carcass weight, (kg)	82,7 ± 3,81 n.s.	93,3 ± 4,30 n.s.
Lean meat, (%)	52,5 ± 2,78 n.s.	54,3 ± 2,41 n.s.

Explanations: n.s. – not significant;* $p < 0,05$; **$p < 0,01$; ***$p < 0,001$

Performance results are given in tab. 2.

There was small effect of the treatments on growth rate. Pigs from the enriched rerainf space of pens had higher growth rates than pigs from the restricted conditions and were heavier at slaughter. Carcass characteristics of the animals from two experimental conditions differed significantly. Carcasses from enriched conditions were much heavier and had smaller lean meat percentage than carcasses of the animals from the restricted conditions.

Results of meat quality assessment are given in tab. 3

There was condition effect for most of the meat quality. The enriched fattening conditions affected lower meat pH, greater water holding capacity and lower shear force comparing to pork from restricted

Tab. 3. Meat quality results

Parameters	Rearing conditions	
	0,5 m^2/pig	1,2 m^2/pig
Meat pH 45 min *post mortem*	6,18 ± 0,02 n.s.	5,88 ± 0,20 n.s.
Meat pH 24 h *post mortem*	5,61 ± 0,009***	5,64 ± 0,007***
Colour L* parameter	49,81 ± 0,42 n.s.	52,24 ± 1,08 n.s.
Colour a* parameter	17,42 ± 0,28 n.s.	16,24 ± 0,21 n.s.
Colour b* parameter	7,02 ± 0,40 n.s.	7,53 ± 0,30 n.s.
Water holding capacity, %	50,57 ± 1,50 n.s.	51,21 ± 1,39 n.s.
Shear force, kg/cm^2	1,57 ± 0,13 n.s.	1,40 ± 0,12 n.s.

Explanations: as in tab. 2.

environments. Although, physical parameters of the colour (L^*, a^*, b^*) were influenced negatively.

The results of study are in agreement with previous, similar studies showing that enrichment of the rearing conditions improves the welfare of pigs by reducing antisocial behavior (25). It is important that housing systems for growing and finishing pigs facilitates separation of functional areas (feeding, resting and dunging area), or prevents direct contact with faeces in the resting area. They should account for the needs of pigs to investigate and manipulate materials and minimize competition. The welfare of pigs appears to be negatively affected by strong reduction of available space and this occurs at all ages. Crowding causes negative effects on physiology, behavior and production (21). In larger rearing space focal animals spent more than a quarter of their time exploring fixtures and the social harmful behavior was not so frequently repeated like in restricted rearing space condition.

In this study small effect of the treatments on growth rate was observed. Pigs from the enriched conditions had higher growth rates than pigs from the less spacious one. Carcass characteristics of the animals from two conditions differed significantly. Animal carcasses from enriched conditions were much heavier and had smaller lean meat percentage than carcasses of pig reared im smaller area. Previous studies on the influence of rearing space on productive performance in pigs have conflicting results. Some reports inform that no difference in fat thickness of pigs reared at different floor-space allowances was observed (6, 10, 11). Whereas, Schaefer et al. (1990) and Horrel (1992) found that enriching the fattening conditions for pigs improves their growth rate. Ruiterkamp (1987) associated high levels of pen mate directed behaviour with reduced feed intake in growing pigs. Our observation shows that higher levels of harmful social behaviour in barren pens lead to lower fed intakes during the finishing period. This type of behaviour may also lead to higher level of stress, which affects food conversion negatively (1).

Rearing space influenced most of the meat quality parameters, although it was not significant. The more spacious conditions resulted in lower meat pH, greater water holding capacity and lower shear force comparing to pork from restricted conditions. All parameters of the colour (L^*, a^*, b^*) were influenced not significantly. Hamilton et al. (2000) found the only effects of housing conditions on pork quality L^* values and lipid levels, which were higher for pigs housed in the spacious compared to the crowded conditions. Therefore, observations made in the current study of a negative effect of rearing conditions on muscle colour and water-holding capacity requires confirmation across a wider range of rearing environments. Studies that have reported on the effects of rearing conditions on pork quality characteristics have generally compared different production systems rather than different conditions within the same system, as in the present study, and have produced conflicting results. Enfalt et al. (1997) found a lower ultimate pH, higher drip loss, increased shear force values, and reduced intramuscular fat for outdoor compared to indoor reared pigs. Wariss et al. (1983) reported that pigs reared intensively had paler meat than pigs reared in a non-intensive system. In contrast, Jones et al. (1994) and van der Wal et al. (1993) compared pigs from outdoor and indoor production systems and found no differences in *longissimus* L^* values. Geverink, de Jong, Lambooij, Blokhuis, and Wiegant (1999) compared pigs reared either in intensive housing conditions or in more extensive conditions, in pens with more space and with straw provided, and found no differences in pork quality between the two methods.

In our study L^* values and lipid levels were higher for pigs housed in the spacious compared to the crowded conditions. But, the enriched fattening condition affected lower meat pH, greater water holding capacity and lower shear force. A possible explanation for the treatment difference is that pigs reared in more spacious conditions had higher levels of intramuscular fat, which has been previously associated with the improved tenderness and water holding capacity in pork (7). This is supported by the finding that pigs from enriched conditions had significantly greater levels of back fat which generally results in higher levels of intramuscular fat (2).

The results of our study are in agreement with previous similar studies. Nearly all of them were exploring influence of enrichment of fattening conditions (organic vs. conventional production). Organic rules for fattening pigs carry out many additional factors: straw, pastures and etc. But the most prevalent housing systems for growing and finishing pigs in Lithuania are pens with slatted or partially-slatted floors in insulated and ventilated buildings (conventional). Fattening pigs usually have *ad libitum* access to automatic feeders or single wet feeders and drinking water as well. Modern commercial pig farms start to implement new technologies for fattening pigs by reducing rearing space. Due to the strict organic animal husbandry re-

gulations, lack of education and information, organic pork is not popular in Lithuania yet.

Conclusions

It can be concluded, that improvement in pigs behavior, performance and meat quality characteristics may be substantial when the difference in housing conditions is substantial. Spacious conditions influenced mainly carcass quality traits and technological meat quality to a lesser extent. The difference in available rearing area for pig is the most affecting factor. Further investigations are required to elucidate of the impact of enriched rearing conditions (environment) of pig and access by them to the outdoor pasture, bedding etc., on their behaviour, performance as well as of the carcass and meat quality.

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Author's address: Viktoras Liorančas, Lithuanian Veterinary Academy, Department of Food Safety and Animal Hygiene, Tilžės 18, 47181 Kaunas, Lithuania; e-mail: viktoras@lva.lt