HOUSING SYSTEMS AND PIG PERFORMANCE – REVIEW

Václavková E., Bečková R.

Institute of Animal Science Prague Uhříněves, Czech Republic

This article is a review of findings about different housing systems-outdoor and indoor- in pig breeding in relation to pig performance and meat quality. Outdoor production system allows animals display their natural behaviour connected with feeding habits and with maternal behaviour. Animals in this production system have better health status but it is necessary to pay attention to parasite control. The outdoor production system is less dependent on input investment and capital. One of negative respects is addiction to climatic conditions. Carcass traits and meat quality parameters are also affected by production system. But it is not possible to clearly specify what kind of production system is better from meat quality point of view. Fatty acid content in meat is mainly affected via diet. Some feeds (for example grass, oil plants) can affect fatty acid content disregarding housing system.

Indoor and outdoor pig production systems and their influence on pig behaviour and health status

Intensive pig farming has moved away from the traditional methods of the past when pigs were allowed to roam freely during the day and sleep in a spacious sty at night. In recent decades pigs are continuously confined to a limited, stimulus-poor space for economical and health reasons, resulting in the production of considerable quantities of high-quality meat. Consumers nowadays are willing to pay extra for pork with certain assurances, including the welfare of pigs being respected (Windghorst, 2001). Alternative housing systems, such as outdoor housing, organic farming and application of environmental enrichment, have gained interest. A major change from conventional to alternative housing systems is that pigs are kept outdoor on paddocks or pasture (Beattie et al., 1996).

Indoor system is the most commonly used production system. Alternative production systems include a variety of systems ranging from partial confinement to complete outdoor systems. Pig performance, immunity and behaviour may be influenced by production system (Rudine et al, 2007). Outdoor pig production is largely concerned with the housing of sows before and after farrowing and the rearing of piglets for the first few weeks of their lives. Pigs are rarely reared to slaughter outside. Best results of growth performance are obtained when outdoor pigs are kept on grass (Patton et al., 2008). Intensive housing systems need higher investment and running costs. Intensive husbandry often leads to animal health and welfare problems. The causes are poor environmental stimuli, perforated hard floors and lack of movement (Horning, 2000). Lower costs and increasing consumer interest were the impulse for using outdoor system in fattening.

The main health problem associated with outdoor housing in organic farming is the occurrence of ectoparasites (Sarcoptes scabiei var. suis , Haematopinus suis, Musca domestica, Demodex phylloides, Boophilus, Amblyomma) and endoparasites (Day et al., 2003). Ascaris (Ascaris suum) and Trichuris (Trichuris suis), characterized by larval development within highly resistent eggs, remain infective under outdoor temperature conditions for 6 to 11 years. A pasture that is clean in the autumn will remain non-infective until the spring irrespective of the level of contamination during the winter. However, accumulated eggs will start developing when the temperature rises and the pasture may become highly infective in the early summer (Burden, 1987). Oesophagostomum spp., Strongyloides ransomi, Isospora suis, Eimeria ssp., are common in outdoor pigs (Thamsborg et al., 1999; Nansen and Roepstorff, 1999). Outdoor herds need a rigorous parasite control program.

Pig behaviour was watched in study performed by Rudine et al. (2007). A conventional indoor housing system was compared with an outdoor system. Indoor reared pigs spent less time standing, outdoor reared pigs spent less time lying. Drinking behaviour was performed less by outdoor pigs. Hötzel et al. (2004) compared the behaviour of sows and piglets during lactation and in the post-weaning period and the behaviour of piglets reared in the outdoors or in confinement conditions. Outdoor sows spent more time standing, walking and exploring the environment than confined sows. During lactation confined piglets spent more time interacting with their mothers, nursing (suckling, massaging udder and fighting for teats), belly-nosing and displaying other oral–nasal and agonistic behaviours directed to penmates than outdoor piglets, while outdoor piglets spent more time feeding and exploring the environment. At and after weaning confined piglets spent more time belly-nosing and displaying agonistic and oral–nasal behaviours directed to penmates than outdoor piglets.

Effect of production system on growth and carcass performance

Feed consumption, climate, space allowance, level of activity, live weight, genotype, health status and stress can affect growth and carcass composition. In environmentally enriched or outdoor housing systems, the level of activity is likely to be increased, which suggests elevated energy requirements for maintenance (Millet et al., 2005). Pigs in an experiment of Petersen et al (1998) showed a slower daily gain and a lower total fat content than individually housed pigs. This can be due to a higher spontaneous activity. If outdoor-housed pigs spend more energy for activity and thermoregulation, it follows that, with an equal feed consumption, a higher proportion of the diet will be used for maintenance requirements. This results in a slower growth and a lower fat content in the pigs at similar age (Lebret et al., 2002; Millet et al., 2005). Effect of production system on daily gain is illustrated in the Table 1.There is no apparent trend towards higher or lower daily weight gain due to outdoor production system (it was increased in three cases and decreased in three cases). In most cases (4 vs. 2) the outdoor system positive affected slaughter weight. Feed use per kg of gain was (in all experiments given I n Table 1) higher in outdoor pigs. It is connected with higher energy demands on moving and body temperature maintenance in cold season. Lebret et al. (2006) connected weight gain with feed consumption – increasing weight gain was caused by increasing feed consumption in outdoor pigs. Effect of production system on lean meat content and fat content in carcass body is illustrated in Table 2.Results given in Table 2 are not clear in favour of outdoor or indoor production system. In most cases (3 vs. 2) the fat content was increased in outdoor pigs.

Similar results were found out by Van der Wal et al (1993) and Hansson et al. (2000) - lower lean meat percentages in free range and organically grown pigs than in conventionally fattened pigs were observed. In contrast, Warriss et al. (1983) found a lower backfat thickness in outdoor- versus indoor-raised animals. Fat content is in negative correlation with lean meat content (Bee et al, 2004; Pugliese et al., 2004). The rate of fat accretion depends on the amount of feed consumed and the rate of protein accretion.

Table 1. Effect of production system on growth parameters based on literature sources (indoor system as reference)

Source	Outdoor pigs		
	Daily weight gain after weaning	Live weight at slaughter (carcass weight)	Feed use (kg/kg)
Bee et al. (2004)	↓	↓	
Gentry et al. (2002)	↑	↑	
Gentry et al. (2004)	↑	↑	↑
Guy et al. (2002)	↓	↓	↑
Kelly et al. (2007)	↔		↑
Lebret et al. (2006)	↑	↑	↑
Patton et al. (2008)	↓	↑	↑
Rudine et al. (2007)	↔	↔	

↑ higher ↓ lower ↔ at the same level

Table 2. Effect of production system on fat and lean meat content based on literature sources (indoor system as reference)

Source	Outdoor pigs	
	Fat content	Lean meat content
Bee et al. (2004)	↓	↑
Estevez et al. (2002)	↑	
Gentry et al. (2002)	↑	
Heyer et al. (2006)	↑	
Högberg et al. (2004)	↔	
Pugliese et al. (2004)	↓	↑

↑ higher ↓ lower ↔ at the same level

Effect of production system on fatty acid content in pig meat

The effect of production system on meat quality was studied by many authors. In Table 3 summary of some results is given. The results are diverging according to feeding strategy. The total PUFA, MUFA and SFA content was increased in three cases and it was also decreased in three cases. Ratio n-6/n-3 PUFA was decreased in most of experiments in outdoor pigs. Nutrition plays very important role in fatty acid deposition in pig tissues. It has major effect on fatty acid profile. Outdoor pigs have access to pasture and important feed components can be supplemented via addition of commercial mixtures. And that´s why results given in Table 3 are not uniform. Fatty acid content depends on feeding mixture composition (fat sources as soya, rapeseed, sunflower oil, linseed). Very important is the role of pasture. Grass is generally considered to have a high content of PUFA n-3 (Högberg et al., 2001). Some studies (Van der Waal et al., 1993; Högberg et al., 2001) found higher levels of polyunsaturated fatty acid in pork of free-ranging pigs than in indoor reared animals, and no differences for monounsaturated fatty acids, when outdoor- pigs had access to fresh pasture. Because of the higher content of PUFA n-3 and n -6 and the lower content of C14:0, C16:0 and C18:0, outdoor pigs had higher PUFA/SFA ratio. This ratio should be above the value of 0.4 to improve the dietetic property of meat, since saturated fatty acids have been implicated in disease associated with modern life, especially in developed countries (Wood et al., 2003).

Effect of production system on meat quality parameters – pH, meat colour, drip loss, juiciness

Several factors of meat quality in relation to alternative housing systems and management systems are described. The meat quality is very often connected with conditions during transport at slaughterhouse and with preslaughter manipulation. The physical activity during loading and transport at slaughter house might not be as demanding physically and might be less stressful. With increasing physical fitness, muscles generate relatively less ATP through anaerobic pyruvate catabolism which reduces muscle lactate formation. Lactate formation following physical stress was significantly lower in physically trained (outdoor pigs with opportunity of more exercise) versus untrained pigs. Higher liver glycogen levels are correlated with a lower ultimate pH. The ultimate pH is measured 24 hours after slaughter. A low ultimate pH results in meat proteins having decreased water-holding capacity and a lighter colour. Conversely, a higher ultimate pH gives a darker colour and less drip loss. Glycogen content and ultimate pH are determined by many factors. Metabolic and contractile properties of muscle are important sources of variation in glycogen content. All the events occurring during the handling of pigs before slaughter can lead to a depletion of muscle glycogen (Fernandez et al., 1991; Geor et al., 1999; Millet et al., 2005). The higher glycogen level before slaughtering would implicate a lower risk for DFD meat, but a greater risk of meat being pale, soft and exudative (PSE).

Table 3. Effect of production system on fatty acid content based on literature sources (indoor system as reference)

Source	Outdoor pigs					
	SFA	**MUFA**	**PUFA**	**n-6 PUFA**	**n-3 PUFA**	**n-6/n-3**
Bee et al. (2004)	↓	↓	↑			↓
Estevez et al. (2003)	↑	↑	↓			↑
Högberg et al. (2004)-females	↑	↓	↑	↑	↔	↓
Högberg et al. (2004)-castrated males	↑	↓	↓	↓	↔	↓
Patton et al. (2008)	↓	↑	↑			
Pugliese et al. (2004)	↓	↑	↓	↓	↔	↓

SFA – saturated fatty acids

MUFA – monounsaturated fatty acids

PUFA – polyunsaturated fatty acids

↑ higher ↓ lower ↔ at the same level

PSE meat occurs more frequently in pig carcasses than DFD meat. PSE meat is caused by severe, short-term stress just prior to slaughter, which leads to a rapid breakdown of muscle glycogen. Outdoor housed pigs seem to cope better with stressful circumstances at slaughter (Millet et al., 2005). Organic housing led to a lower ultimate pH in the experiments of Millet et al. (2004). Guy et al. (2002) saw lower initial pH values (1 hour after slaughter) for outdoor-housed pigs although not statistically significant. Klont et al. (2001) determined a higher ultimate muscle pH (pH =5,68) at 24 h post mortem in pigs on a straw bedding.

Meat colour is influenced by different factors like post-mortem glycolysis rate, intramuscular fat content, pigment level and oxidative status of the pigment (VanOeckel et al., 1999; Lindahl et al., 2001). Gentry et al. (2004) found no differences in colour or fibre type distribution between conventional pigs and pigs with increased space allowance, while Bridi et al. (1998) observed more red meat in outdoor-housed pigs and Millet et al. (2004) found more red and darker meat in organically housed pigs. In the experiment by Lebret et al. (2006) the outdoor system slightly increased meat yellowness (b* value), whereas redness (a*) and lightness (L*) were unaffected. Higher free water content, higher L* and b* value were found in outdoor pork by Pugliese et al. (2004).

Sensorial quality of pork is affected by production condition. In experiment with outdoor and indoor pigs (Gentry et al., 2002) increasing pork flavour intensity scores of loin chops from outdoor pigs were observed. The indoor-reared pigs in a study by Enfält et al. (1997) showed lower shear force values of meat and greater meat tenderness and juiciness than outdoor reared pigs. In a study by Petersen et al. (1997) exercise of the pigs had a negative effect on the tenderness scores (by taste panel) of the M. longissimus dorsi, but shear force values were not affected.

Conclusion

Many different factors play role in pig meat production and quality. The main factor influencing meat quality, especially fatty acid content, is nutrition. Components in feeding mixtures (linseed, olive, rapeseed, sunflower, soy oil) can change fatty acid profile in meat without changing carcass traits. Outdoor production system has both benefits and disadvantages for farmers and pork producers. This system allows animals display their natural behaviour connected with feeding habits and with maternal behaviour. Animals in this production system have better health status but it is necessary to pay attention to parasite control. The outdoor production system is less dependent on input investment and capital. One of negative respects is addiction to climatic conditions. That´s why weaning and growth performance of outdoor herds can be more variable year by year. Carcass traits and meat quality parameters are also affected by production system.

But it is not possible to clearly specify which production system – outdoor vs. indoor – is better from meat quality point of view. Fatty acid content in meat is mainly affected via diet. Some feeds (for example grass, oil plants) can affect fatty acid content disregarding housing system.

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Supported by the Ministry of Agriculture of the Czech Republic (Project MZE 0002701403)