

IMPACT OF VARIOUS HOUSING CONDITIONS ON THE OCCURRENCE OF PATHOLOGICAL LESIONS IN SLAUGHTERED PIGS

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Abstract

Introduction. This study assessed the effect of farming system, feeding system, floor type, housing density and gender on the occurrence of pathological lesions in slaughtered pigs.

Materials and Methods. The study was conducted on 400 pigs from four farms with different housing conditions. The plucks of 100 slaughtered pigs from each farm were examined for pneumonia, pleurisy, pericarditis and milk spots.

Results and Conclusions. Pigs housed in a large-scale indoor farm had the lowest incidence of pneumonia. The highest occurrence of pneumonia was recorded in pigs fattened in a small-scale farm in pens with outdoor access. Pigs reared on farms in pens with outdoor access had the highest incidence of milk spots. Pigs from farms using pellet feeding systems had higher incidences of pneumonia, pleurisy and milk spots than those from a farm using a liquid feeding system. A rearing system comprising concrete floors without bedding resulted in the highest incidence of pneumonia in pigs. Pigs from a farm using a concrete floor with bedding had the highest occurrence of milk spots. The lowest incidence of milk spots was recorded in pigs from farms using fully-slatted floors. Compared to low housing density, high housing density resulted in higher incidences of pneumonia, pericarditis and milk spots in pigs. A higher prevalence of lung lesions was detected in barrows than in gilts. This study showed the most significant risk factors for

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the occurrence of pathological lesions in slaughtered pigs are pens with outdoor access, pellet feeding system, concrete floor, high housing density and gender.

Key Words: farming system, feeding system, floor type, housing density, gender, pathological lesions

INTRODUCTION

Pig production aims to produce animals with high meatiness and good pork quality traits at the same time. However, current pig production favors the occurrence of subclinical diseases, which are impossible to assess by clinical observation on the farm of origin (Dalmau et al., 2014). Pneumonia, pleurisy, liver milk spots and pericarditis are the most frequent pathological lesions in organs observed at the slaughterline and they are considered to be an important indicator of pig health and welfare on the farm of origin (Sánchez et al., 2018; Sanchez-Vazquez et al., 2012; Welfare Quality® protocol, 2009).

Slaughterhouse detected pathologies reflect environmental conditions on the farm of origin and cause significant economic losses due to decreased average daily weight gain, growth rate and feed conversion efficiency and increased morbidity, mortality, medication and veterinary expenses (Jäger et al. 2012; Sanchez-Vazquez et al., 2010). Financial losses to the meat industry then occur because a high prevalence of pathological lesions decreases carcass and pork quality (Čobanović et al., 2017; Karabasil et al., 2017), increases the carcass and viscera trimming procedures, reduces the slaughterline speed for a more detailed inspection of suspect carcasses and increases labor needed to handle the carcasses, resulting in disposal of organs unfit for human consumption (Teixeira et al., 2016; Stygar et al., 2016; Harley et al., 2012; Jäger et al., 2012).

The environmental factors, which can condition the pig production systems and play an important role in the development of subclinical respiratory and parasitic diseases detected in pigs at slaughter, can be classified into the following groups: (i) housing conditions, (ii) hygiene, (iii) ventilation, (iv) climatic parameters, and (v) herd characteristics (Fablet et al., 2012; Sanchez-Vazquez et al., 2010; Stärk, 2000). It has been reported that various housing conditions such as farm size, outdoor/indoor farming, housing density, mixing of pigs from different herds, feeding system, floor and bedding type, are the major factors that can stimulate the occurrence of subclinical pathological lesions in fattening pigs (Fablet et al., 2012; Sanchez-Vazquez et al., 2010). In addition, several studies (van Staaveren et al., 2016; Jaeger et al., 2009) showed predisposition for the occurrence of pathological lesions in organs can differ between pig genders. Therefore, the aim of this study was to examine the effect of farming system, feeding system, floor type, housing density and gender on the occurrence of pathological lesions in slaughtered pigs.

MATERIALS AND METHODS

Experimental animals and study farms

The study was conducted between 1 October and 1 December 2018 on 400 pigs (211 barrows and 189 gilts, crossbreeds Yorkshire × Landrace, with average live weight of approximately 110 kg and 6 months old) originating from four commercial farms. Each herd was visited once to collect information about the farm of origin.

Farm A (small-scale farm) produced only fatteners and consisted of one fattening unit with the capacity to finish a maximum of 200 pigs per year. The fattening unit consisted of two pens with outdoor access containing about 50 pigs each. Pigs were kept in pens on a concrete floor without bedding at an average density of 0.5 m² per pig. Dry-pellets were given *ad libitum* during the entire fattening period. This farm used a continuous flow system of management with the monthly introduction of pigs and fortnightly departures to the slaughterhouse. There was no parasite control and no ongoing vaccination program against respiratory diseases.

Farm B (large-scale farm) was a conventional farrow-to-finish herd practicing an all-in/all-out management with confined (i.e. indoor) sows, weaners and fattening pigs. The farm has 650 breeding sows and produces about 12,500 fattening pigs a year. Pigs were housed in a finishing facility on a slatted floor, in groups of 20 animals per pen, at an average density of 1.0 m² per pig. Animals were fed *ad libitum* with liquid feed during the entire fattening period. Parasite control included the following measures: the mandatory dehelminthization of breeding sows 10-15 days prior to artificial insemination, as well as 10-15 days prior to the expected farrowing, of boars every 6 months, and of the weaned piglets before their removal to the feedlot. Choice of anthelmintic was changed on a rotating basis after each batch of pigs. There was no ongoing vaccination program against respiratory diseases.

Farm C (small-scale farm) produced only fatteners and consisted of two fattening units with capacity to finish a maximum of 200 pigs per year. Each unit consisted of two pens containing about 25 pigs each, all of which were fed *ad libitum* with dry pellets. Pigs were kept indoors in pens on a slatted floor at an average density of 0.75 m² per pig. Farm used a continuous flow system of management with the monthly introduction of pigs and fortnightly departures to the slaughter plant. There was no parasite control and no ongoing vaccination program against respiratory diseases.

Farm D (large-scale farm) was a conventional farrow-to-finish herd practicing an all-in/all-out management with free-range (i.e. outdoor) sows and confined (i.e. indoor) weaners and fattening pigs. The farm has 1,300 breeding sows and produces about 18,000 fattening pigs a year. Pigs were kept in a finishing facility on a concrete floor with straw bedding, in groups of 25 animals per pen, with average space allocation of 0.60 m² per pig. Dry-pellets were given *ad libitum* during the entire fattening period. Parasite control includes the following measures: the mandatory dehelminthization of breeding sows 10-15 days prior to artificial insemination, as well as 10-15 days

prior to the expected farrowing, of boars every 6 months, and of the weaned piglets before their removal to the finishing facility. Choice of anthelmintic was changed on a rotating basis after each batch of pigs. There was no ongoing vaccination program against respiratory diseases.

The treatment conditions, both before and after slaughter, were identical for all pigs and in accordance with the conventional industrial practice. Pig slaughter and carcass processing were performed at the same small-scale commercial slaughterhouse with a daily slaughter rate of approximately 35 pigs.

Slaughterline examination

The plucks (heart, lung and liver set from each pig) of 100 slaughtered pigs from each farm were removed from the slaughterline and visually appraised and palpated for macroscopically visible lesions of pneumonia, pleurisy, pericarditis and liver milk spots according to the Welfare Quality® protocol (2009). A positive case for each pathological lesion was defined as a pig organ affected with any degree of lesion (score 2) and a negative when lesions were absent (score 0). The complete assessment of pathology scores was performed by the three trained investigators.

Statistical analysis

Statistical analysis of the results was conducted using software SPSS version 23.00 for Windows (SPSS, 2015). Based on farming system, pigs were allocated to four groups: large scale indoor farm (n=100); large-scale farm with outdoor access (n=100); small-scale indoor farm (n=100); and small-scale farm with outdoor access (n=100). According to feeding system, pigs were allocated to two groups: liquid feeding system (n=100); and pellet feeding system (n=300). Furthermore, based on housing density, pigs were classified in two groups: low housing density: $>0.60 \text{ m}^2/\text{pig}$ (n=200), and; high housing density: $<0.75 \text{ m}^2/\text{pig}$ (n=200). Animals were divided into three groups according to floor type: slatted floor (n=200); concrete floor without bedding (n=100); and concrete floor with bedding (n=100). In addition, based on gender, pigs were allocated to two groups: barrows (n=211); and gilts (n=189). The occurrence of pathological lesions in slaughtered pigs in relation to the feeding system, housing density and gender was determined by Fisher's exact test. The Chi-square test was used to determine the occurrence of pathological lesions in slaughtered pigs with respect to the farming system and floor type. In all cases, values of $P < 0.05$ were considered significant.

RESULTS

The effect of farming system on the occurrence of pathological lesions in slaughtered pigs is depicted in Table 1. Farming system had a significant influence ($P<0.05$) on the occurrence of pneumonia, pleurisy and liver milk spots in slaughtered pigs.

Table 1. Effect of farming system on the occurrence of pathological lesions in slaughtered pigs (n=400)

Farming system	Large-scale farm		Small-scale farm		P -value	Significance
	Indoor	Outdoor access	Indoor	Outdoor access		
n	100	100	100	100		
Pathological lesion (%)						
Pneumonia	33.00 ^a	49.00 ^b	43.00 ^b	64.00 ^c	0.0002	*
Pleurisy	14.00 ^a	33.00 ^b	30.00 ^b	21.00 ^{ab}	0.0068	*
Liver milk spots	25.00 ^a	65.00 ^b	21.00 ^a	40.00 ^c	<0.0001	*
Pericarditis	3.00 ^a	11.00 ^b	6.00	10.00	0.1161	NS

* Statistical significance at ($P<0.05$); NS: not significant ($P>0.05$).

– Different letters in the same row indicate a significant difference at $P<0.05^{(a-c)}$.

The effect of feeding system on the occurrence of pathological lesions in slaughtered pigs can be seen in Table 2. Feeding system had a significant impact ($P<0.05$) on the occurrence of pneumonia, pleurisy and liver milk spots in slaughtered pigs.

Table 2. Effect of feeding system on the occurrence of pathological lesions in slaughtered pigs (n=400)

Feeding system	Liquid feeding	Pellet feeding	P-value	Significance
n	100	300		
Pathological lesion (%)				
Pneumonia	33.00 ^a	52.00 ^b	0.0012	*
Pleurisy	14.00 ^a	28.00 ^b	0.0047	*
Liver milk spots	25.00 ^a	42.00 ^b	0.0028	*
Pericarditis	3.00	7.00	0.1068	NS

* Statistical significance at ($P<0.05$); NS: not significant ($P>0.05$).

– Different letters in the same row indicate a significant difference at $P<0.05^{(a-b)}$.

The effect of floor type on the occurrence of pathological lesions in slaughtered pigs is shown in Table 3. Floor type had a significant effect ($P<0.05$) on the occurrence of pneumonia, pleurisy and liver milk spots.

Table 3. Effect of floor type on the occurrence of pathological lesions in slaughtered pigs (n=400)

Floor type	Slatted floor	Concrete floor without bedding	Concrete floor with bedding	P-value	Significance
n	200	100	100		
Pathological lesion (%)					
Pneumonia	38.00 ^a	64.00 ^b	49.00 ^a	0.0001	*
Pleurisy	22.00 ^a	50.00 ^b	33.00 ^c	<0.0001	*
Liver milk spots	23.00 ^a	40.00 ^b	65.00 ^c	<0.0001	*
Pericarditis	4.50 ^a	10.00	11.00 ^b	0.0720	NS

* Statistical significance at ($P<0.05$); NS: not significant ($P>0.05$).

– Different letters in the same row indicate a significant difference at $P<0.05^{(a-c)}$.

The effect of housing density on the occurrence of pathological lesions in slaughtered pigs is reported in Table 4. The occurrence of pneumonia, liver milk spots and pericarditis significantly differed ($P<0.05$) between pigs in low and high housing density.

Table 4. Effect of housing density on the occurrence of pathological lesions in slaughtered pigs (n=400)

Housing density	Low	High	P-value	Significance
n	200	200		
Pathological lesion (%)				
Pneumonia	38.00 ^a	56.50 ^b	0.0003	*
Pleurisy	28.21	27.50	0.2465	NS
Liver milk spots	23.00 ^a	52.50 ^b	<0.0001	*
Pericarditis	4.50 ^a	10.50 ^b	0.0352	*

Low housing density: >0.60 m²/pig; high housing density: <0.75 m²/pig.

* Statistical significance at ($P<0.05$); NS: not significant ($P>0.05$).

– Different letters in the same row indicate a significant difference at $P<0.05^{(a-b)}$.

Table 5. Effect of gender on the occurrence of pathological lesions in slaughtered pigs (n=400)

Gender	Barrows	Gilts	P-value	Significance
n	211	189		
Pathological lesion (%)				
Pneumonia	54.50 ^a	39.15 ^b	0.0026	*
Pleurisy	29.38 ^a	19.05 ^b	0.0197	*
Liver milk spots	35.55	40.21	0.3538	NS
Pericarditis	7.58	5.85	0.5522	NS

* Statistical significance at ($P<0.05$); NS: not significant ($P>0.05$).

– Different letters in the same row indicate a significant difference at $P<0.05^{(a-b)}$.

The effect of gender on the occurrence of pathological lesions in slaughtered pigs is shown in Table 5. The occurrence of pneumonia and pleurisy differed significantly ($P<0.05$) between the pig genders.

DISCUSSION

In the present study, pigs housed in a large-scale indoor farm had the lowest ($P<0.05$) incidence of pneumonia, while the highest ($P<0.05$) occurrence of pneumonia was recorded in pigs fattened in a small-scale farm in pens with outdoor access (Table 1). In addition, pigs reared in large- and small-scale farms in pens with outdoor access had the highest ($P<0.05$) incidence of liver milk spots compared to the other farming systems (Table 1). Pigs reared on small-scale farms in barns with outdoor access are more susceptible to respiratory diseases, because they are more exposed to adverse weather conditions such as dust, wind, rain, snow and especially extreme external temperature and humidity fluctuations (Done, 1991). Furthermore, small-scale finishing farms that use a continuous flow system of management are considered at higher risk of respiratory disease than farrow-to-finish farms as they rely on other sources for weaner restocking, which increases the chance of introducing infectious agents from outside the herd (e.g. with carrier pigs) (Stärk, 2000; Done, 1991). A high percentage of fattening pigs with liver milk spots from both small- and large-scale farms could also be a reflection of the pens with outdoor access, which might have led to greater ascarid transmission (Thomsen et al., 2001). Therefore, pig farms, regardless of their capacity, where indoor growing took place in all phases of production, have a lower risk of liver milk spots (Done, 1991). Accordingly, the higher hygiene standards in housed production limit the within-herd ascarid transmission, despite the fact that *Ascaris suum* is capable of completing its life cycle indoors, but with fewer viable parasites than in barns with outdoor access (Roepstroff and Nansen, 1994).

In this study, pigs from farms using pellet feeding systems had significantly higher ($P<0.05$) incidences of pneumonia and pleurisy than pigs from the farm using a liquid feeding system (Table 2). This could be ascribed to the facts that the pellet feeding system increases the presence of aerial dust, and so this practice could lead to an increase in the occurrence of lung lesions in slaughtered pigs (Gill, 2007). On the other hand, the liquid feeding system has an indirect benefit for general pig health status, especially by stimulating the digestion process. Also, wet-feeding has an extremely important direct benefit on lung health by reducing the presence of aerial dust in pig barns (Gill, 2007). Investigating the effect of the feeding system, a higher incidence ($P<0.05$) of liver milk spots was detected on farms using a pelleted feed than on the farm not employing this feed form (Table 2). This agrees with the findings of Petkevicius et al. (1997) and could be attributed to the level and chemical form of non-starch polysaccharides (NSPs) present in this processed feed form, as the pelleting process could have modified the NSPs and gut microbiota. Hence, feeding pigs with high dietary fiber diets leads to disturbance of the gastrointestinal tract microbiota,

which accelerates the development and proliferation of intestinal parasites such as *Ascaris suum* (Petkevicius et al., 1997). In contrast, it has been reported that farms using wet-feeding systems appeared to be at lower risk for the occurrence of liver milk spots, which may be connected to the overall benefits of liquid feeding on the intestinal lumen environment and by favoring the digestion processes (Gill, 2007). Therefore, use of the liquid feeding system with probiotics would have positive effects on gut microbiota and the digestion process, creating unfavorable conditions for the development and proliferation of *Ascaris suum* and, thus, reducing the occurrence of milk spots in the livers (Gill, 2007; Petkevicius et al., 1997).

In this investigation, pigs from the farm using a concrete floor without bedding had a higher ($P<0.05$) incidence of pneumonia compared to pigs from farms not having this type of floor (Table 3). These results are in agreement with previous studies, which reported that solid floors without bedding appear to be a consistent risk factor for higher prevalences of lung lesions, whereas the use of a concrete floor with bedding could be beneficial in insulating the pig from the cold floor (Sanchez-Vazquez, 2013; Stärk, 2000). In addition, pigs from the farm using a concrete floor with bedding had the highest ($P<0.05$) incidence of liver milk spots, while the lowest incidence ($P<0.05$) of milk spots in the livers was recorded in pigs from farms using fully slatted floors (Table 3). Several studies (Sanchez-Vazquez, 2013; Roepstorf and Jorsal, 1990) reported a slightly reduced risk for the occurrence of liver milk spots for farms where pigs were reared on fully slatted floors compared to those not having this type of floor. On the other hand, it has been reported that farms having finishing buildings constructed with solid floors and using bedding are a consistent risk factor for higher occurrence of liver milk spots (Sanchez-Vazquez, 2013). This may be explained by the facts that bedding material could provide a protective environment for the *Ascaris suum* eggs and can hamper the effectiveness of routine cleaning and disinfection protocols to destroy parasite eggs, which than can survive longer and develop to infective stages (Dangolla et al., 1996). As a result of being on the rearing system of concrete floors with bedding, pigs have greater contact with feces, facilitating fecal-oral parasite transmission, which might have led to greater ascarid transmission in finishing pigs reflected in more livers becoming affected with milk spots (Sanchez-Vazquez, 2013; Dangolla et al., 1996).

In this research, pigs kept under high housing density had significantly higher ($P<0.05$) incidences of pneumonia, pericarditis and liver milk spots than pigs kept under low housing density. It has been reported that decreasing the space allowance per pig generally leads to overcrowding and might have detrimental effects on health, especially the respiratory (Alawneh et al., 2018) and gastrointestinal systems (Thomsen et al., 2001). During the current investigation, pigs housed at high stocking density (<0.60 m²/pig) had less allocated space than the current minimum space allotment of 0.65 m² (for pigs between 85 kg and 110 kg) suggested by the European Union (Council Directive, 2008), likely predisposing pigs to respiratory and parasitic diseases and, thereby, contributing to the numerous cases of lung lesions and liver milk

spots recorded in this study. The effect of overcrowding on respiratory health can be connected to aerosol spread between pen mates or for more opportunities for direct nose-to-nose contacts with an infected pig (Alawneh et al., 2018). The higher occurrence of pericarditis in pigs kept at high housing density can be explained by the fact that pericarditis in pigs is typically secondary to or associated with some primary respiratory lesions, whereby inflammation usually spreads from the lungs as a result of the lymphohematogenous dissemination of infectious agents such as *Mycoplasma* spp., *Haemophilus* spp., *Actinobacillus pleuropneumoniae* and *Streptococcus* spp. (Leps and Fries, 2009). In addition, when pigs are kept under high housing density, especially in dirty isolated barns with the improper and irregular disposal of manure and sewage, fecal-oral parasite transmission is facilitated, which allows maintenance of *Ascaris suum* infection in the pig population.

In this study, barrows were more affected by pneumonia and pleurisy than were gilts ($P < 0.05$), which is consistent with the findings of van Staaveren et al. (2016) and Jaeger et al. (2009). According to Prunier et al. (2006), surgical castration of pigs could negatively affect their general health status in the long term. These authors suggest that barrows have a higher predisposition to chronic inflammatory diseases, which could be explained by the pigs' lack of androgens. It is known that these hormones suppress both B-cell and T-cell immune responses and, thus, decrease disease expression. This is the likely reason for the difference found between genders in the incidence of lung lesions.

CONCLUSION

This study showed the most significant risk factors for the occurrence of pathological lesions in slaughtered pigs are pens with outdoor access, pellet feeding system, concrete floor with or without bedding, high housing density and gender. Education of farmers through a suitable veterinary extension service on improving pig management, adequate veterinary care, and effective prevention, treatment and control of pig infectious and parasitic diseases is of paramount importance so that farmers accordingly adjust pig housing and hygiene conditions, adopt deworming and vaccination protocols and break disease cycles. A change from smallholder pig production systems to the modern indoor farming system, adequate veterinary care, good hygiene and appropriate housing conditions would reduce the prevalence of pathological lesions in slaughtered pigs and improve pig health and welfare.

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Authors contributions

NK and NČ defined the research theme, gave the conception of the research and carried out experimental part of the study. JCU and KM have made supervised the analysis of the results, and contributed to the writing of the manuscript. KA and ŠM were involved in drafting the manuscript and revising it critically for important intellectual content and have made a substantial contribution to conception and design, analysis and interpretation of data. All authors discussed the results and contributed to the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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UTICAJ RAZLIČITIH USLOVA UZGOJA NA POJAVU PATOLOŠKIH PROMENA NA ORGANIMA ZAKLANIH SVINJA

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Kratak sadržaj

Uvod. Cilj ovog istraživanja bio je da se utvrdi uticaj tipa farme, način ishrane, tipa poda, dostupne podne površine u boksovima i pola na pojavu patoloških promena na organima zaklanih svinja.

Materijal i metode. Ispitivanje je sprovedeno na 400 svinja koje su poticale sa četiri komercijalne farme sa različitim uslovima uzgoja. U cilju utvrđivanja prisustva patoloških promena na unutrašnjim organima svinja, kompleti organa (pluća, srce i jetra) od 100 svinja sa svake farme su pregledani adspekcijom i palpacijom na liniji klanja na prisustvo pneumonija, pleuritisa, perikarditisa i mlečnih pega na jetri.

Rezultati i zaključak. Svinje uzgajane na farmi velikog kapaciteta u boksovima bez ispusta su imale najmanju učestalost pneumonija, dok je najveća prevalencija patoloških promena na plućima zabeležena kod svinja sa farme malog kapaciteta koje su uzgajane u boksovima sa ispuatom. Kod životinja koje su uzgajane na farmama u boksovima sa ispuatom utvrđena je najveća učestalost mlečnih pega na jetri. Ishrana svinja peletiranom hranom rezultirala je većom pojavom pneumonija, pleuritisa i

mlečnih pega na jetri u poređenju sa ishranom svinja kašastom hranom. Uzgoj svinja na betonskom podu bez prostirke rezultirao je najvećom pojavom pneumonija. Najveća učestalost mlečnih pega na jetri zabeležena je kod svinja koje su uzgajane na betonskom podu sa prostirkom, a najmanja pojava mlečnih pega na jetri je utvrđena kod svinja koje su držane na celorešetkastom podu. U poređenju sa malom dostupnom podnom površinom u boksovima, velika dostupna podna površina u boksovima imala je za posledicu veću učestalost pojave pneumonija, perikarditisa i mlečnih pega. Kod kastrata je utvrđena veća učestalost patoloških promena na plućima u poređenju sa nazimicama. Na osnovu rezultata ovog istraživanja može se zaključiti da su boksovi sa ispustom, ishrana peletiranom hranom, uzgoj na betonskom podu, mala dostupna podna površina u boksovima i pol najznačajni faktori rizika za pojavu patoloških promena na organima svinja.

Ključne reči: tip farme, način ishrane, tip poda, gustina naseljenosti, pol, patološke promene