Causes and factors related to pig carcass condemnation

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ABSTRACT: *Ante mortem* and *post mortem* carcass condemnation records could be of use as a potential database for the study of swine diseases, epidemiology or animal welfare. Thus, the aim of this study was to investigate the causes of *ante mortem* rejections and *post mortem* carcass condemnation of pigs intended for human consumption during a 78-month period. The records considered for study were, date of slaughter, total pigs slaughtered and total number of *ante mortem* rejections (deaths during transportation and deaths in the pens) and *post mortem* carcass condemnations (osteomyelitis, caseous lymphadenitis, erysipelas, cachexia, pale, soft and exudative meat (PSE), bloody meat, muscular necrosis, purulent nephritis, purulent metritis, jaundice, meats from febrile pigs and peritonitis). The influence of several factors such as year, season, mandatory fulfilment of a food chain information form (FCIf) and compulsory certification of swine drivers/transporters on *ante mortem* rejections and *post mortem* carcass condemnation was also studied. A total of 161 001 pigs slaughtered resulted in 238 (0.15%) *ante mortem* deaths, 160 763 pigs processed for meat consumption (99.7%) and 392 (0.24%) carcass condemnations. The *ante mortem* rejections revealed that 146 pigs (61.3%) died during transportation whereas 92 (38.7%) were rejected due to death in pens. The main causes of carcass condemnations were osteomyelitis (38.5%), granulomatous lymphadenitis (22.7%) and pleurisy/pneumonia (21.2%). A relationship was found between the month and *ante mortem* condemnations ($P < 0.01$), death losses during transport ($P < 0.01$) and between compulsory certification of animal transporters and deaths by transportation ($P < 0.05$). During the cold season, the probability of *ante mortem* rejections (OR = 1.84; CI 95%: 1.32–2.59) and death in pens (OR = 1.62; CI 95%: 1.02–2.57) was higher. The compulsory fulfilment of a food chain information form was not revealed to be significantly linked with the total number of carcass condemnations although the odds of *ante mortem* rejections were higher (OR = 2.10; CI 95%: 1.44–3.08) when it was not mandatory. Higher *post mortem* condemnations compared to *ante mortem* condemnations can be explained by the fact that several *post mortem* findings are asymptomatic in live animals. A progressive decrease in losses during transport was associated with on-farm improvements in animal welfare measures in addition with compulsory training of animal transporters. However, the consistent values of deaths in pens throughout the study period, with an increase during the winter, indicate a need for an improvement in the thermal conditions of the holding area in slaughterhouse. Regarding the *post mortem* condemnations, the improvement in animal welfare conditions may explain the decrease in osteomyelitis condemnations while the environmental origin of granulomatous lymphadenitis may be associated with region, climate or with the presence of hosts that may explain the influence of the time of year on its variations. The FCIf was implemented as a measure to improve the transparency of food safety and animal health in the food chain from farm to fork. Although osteomyelitis and granulomatous lymphadenitis condemnations were influenced by the FCIf, this relationship cannot be fully explained due to the scarce information related to disease prevalence and/or diagnostics at the farm level. Consequently, the improvement in food safety elicited by this measure is not entirely clear. Data on carcass condemnation could be used to verify the emergence, evolution and control of swine diseases as well as to improve animal health, food safety and veterinary public health programs and/or strategies according to the epidemiological context, with the ultimate aim of guaranteeing public health.

Keywords: carcass; *ante mortem*; *post mortem*; condemnation; transportation

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Briefly, the process of pig slaughtering involves pig transportation, unloading to the lairage, veterinary *ante mortem* inspection, stunning, dressing, veterinary *post mortem* inspection, stamping and delivering (Moreno Garcia 2003).

In the European Union, the transportation of pigs to the slaughterhouse must be carried out by drivers that hold a certificate of competence in vehicles previously approved by the national veterinary authority for animal transportation (Regulation (EC) 1/2005). All the documents regarding pigs, drivers and vehicle authorisation must be carried by the driver.

Once at the slaughterhouse, all pigs are subjected to *ante mortem* inspection by the official veterinary meat inspector (OVI). Pigs suspected to be diseased or injured are screened out for isolation slaughter. Moreover, all the documents regarding pig identification, drivers and vehicle approval and authorisation are also inspected by the OVI. Pigs approved at *ante mortem* inspection are slaughtered. After the dressing of the carcass, all of the carcass and offal are then inspected by the OVI. Only the meat and offal that are fit for human consumption will be approved by the OVI whereas unfit meat, offal or parts of the carcass will be condemned as described in Regulation (EC) 854/2005.

The records of *ante mortem* and *post mortem* causes of pig carcass condemnation at slaughterhouses constitute a potential database for studies regarding swine diseases and conditions responsible for total or partial carcass and/or offal condemnations (Gracey et al. 1999). The literature available regarding the causes of carcass condemnations in pigs is scarce. However, reports on the partial condemnation of swine carcasses and its economical implications, condemnation causes in growth-retarded pigs and the utilisation of records of pig condemnations as a spatial disease surveillance method have recently been published (Tuovinen et al. 1994; Tiong and Bin 1999; Martinez et al. 2007; Thomas-Bachli et al. 2012, 2014).

Ante mortem inspection can also be used as an indicator of pig welfare at the farm, during transportation, at unloading and during rest in pens (Shimshony and Chaudry 2005).

In order to verify the relationship between pigs carcass condemnation and swine diseases and food safety, the aim of this study was to investigate the causes of *ante mortem* rejections and *post mortem* carcass condemnation of pigs intended for human consumption during a 78-month period and the influence of factors such as year, season, compulsory fulfilment of the food chain information form (FCIf) or the compulsory certification of drivers.

MATERIAL AND METHODS

Animals and lesions. A total of 161 001 pigs intended for human consumption were studied. All pigs were approximately six months old and presented with a live weight of about 100 kg. After slaughtering and dressing, the carcasses weighed approximately 80 kg. All studied pigs came from swine farms of the region of Lisbon and the Tejo Valley. In Portugal there are a total of 2 024 000 pigs of which 1 015 000 were located in the region of study. The main aspects of swine management include breeding and production holdings. All data regarding *ante mortem* and *post mortem* condemnations were obtained directly by the authors between August and September 2012, from two slaughterhouses of the region of Tras-os-Montes e Alto Douro, northern Portugal. The average distance from swine farms to slaughterhouses is approximately 350 kilometres. The study of causes of carcass condemnation was carried out on pigs condemned over a 78-month period, from March 2006 to July 2012. The two slaughterhouses included in this study processed swine using a similar principal technique and the rate of pigs slaughtered per unit of time and pigs slaughtered came from the same previously described region.

The records considered for study were date of slaughter, total pigs slaughtered and total number of *ante mortem* rejections and *post mortem* carcass condemnations.

The causes of *ante mortem* rejections were classified into two categories: deaths during transportation and deaths in the pens. The causes recorded at *post mortem* carcass condemnation were osteomyelitis, caseous lymphadenitis, erysipelas, cachexia, pale, soft and exudative meat (PSE), bloody meat, muscular necrosis, purulent nephritis, purulent metritis, jaundice, meats from febrile pigs and peritonitis. All causes of *post mortem* carcass condemnation are described in the Regulation (EC) 854/2004. Partial carcass and offal condemnations were not considered for the study due to the absence of records at slaughterhouses.

For the purposes of this study, we considered the total pigs to be the sum of *ante mortem* rejections and the total pigs slaughtered (i. e. approved at *ante*

mortem inspection). In addition, the influence of the following factors: year, season, FCIf and certification of swine drivers/transporters were considered. A food chain information form was compulsory after January 2010 whereas the certification of swine drivers/transporters was compulsory after 2008. No demographic parameters such as sex, breed and carcass conformation were considered.

Data analysis. Chi-squared (χ^2) tests were used to compare variables. Analyses were done with SPSS 19.0 software (SPSS Inc., Chicago) for Windows considering a probability (P) of less than 0.05 as statistically significant.

To perform the univariate analysis, the categories "year" and "season" were encoded as follows: period 1 (from March 2006 to December 2008) and period 2 (from January 2009 to July 2012); temperate season (spring and summer) and cold season (autumn and winter).

Statistical associations between *ante mortem* rejections and carcass condemnations and influencing factors such as period, season and FCIf were calculated. Multivariate logistic regression was applied initially; however, the goodness of the fit test was not acceptable after the test run. In consequence, potential associated factors significant at $P < 0.05$ (two-tailed; alpha = 0.05) were investigated using univariate logistic regression to model odds (OR = *odds ratio*) and the confidence interval (95%) of association between factors of interest and condemnations.

RESULTS

During the study period (Table 1), a total of 161 001 pigs were subjected to slaughter. Two hundred and thirty-eight (0.15%) were rejected during the *ante mortem* inspection, 160 763 (99.9%) pigs were slaughtered and 392 (0.24%) were condemned during the *post mortem* inspection.

The *ante mortem* rejections revealed that 146 pigs (61.3%) died during transportation whereas 92 (38.7%) were rejected due to death in pens. The univariate analysis showed that *ante mortem* rejections were higher in pigs slaughtered in the period 2

Table 1. Total pigs slaughtered and causes of *ante mortem* rejections and *post mortem* carcass condemnation

	n	%[a]	%[b]	%[c]
Total pigs	161 001	100		
Total slaughtered	160 763	99.85		
Total a*nte mortem* rejections	238	0.15		
Total deaths during transportation	146	0.09	61.34	
Total deaths in pens	92	0.06	38.66	
Total *post mortem* carcass condemnations	392	0.24		
Osteomyelitis	151	0.09		38.52
Pleurisy/pneumonia	83	0.05		21.17
Abscesses	33	0.02		8.42
Generalised melanosis	7	< 0.01		1.79
Granulomatous lymphadenitis	89	0.06		22.70
Erysipela	3	< 0.01		0.77
Caquexia	7	< 0.01		1.79
Pale soft and exudative (PSE) meat	2	< 0.01		0.51
Bloody meat	1	< 0.01		0.26
Muscular necrosis	1	< 0.01		0.26
Purulent nephritis	1	< 0.01		0.26
Purulent metritis	2	< 0.01		0.51
Jaundice	1	< 0.01		0.26
Febrile meat	1	< 0.01		0.26
Peritonitis	10	0.01		2.55

[a]expressed as a percentage of the total number of pigs, [b]expressed as a percentage of the total number of *ante mortem* rejections, [c]expressed as a percentage of the total number of *post mortem* carcass condemnations

Table 2. Factors influencing of *ante mortem* rejections and *post mortem* carcass condemnation

	Month	Year	Season	FCI	DC
Ante mortem rejections	< 0.01	< 0.05	< 0.05	< 0.001	ns
Deaths during transportation	< 0.01	ns	ns	< 0.01	< 0.05
Deaths in pens	ns	ns	< 0.01	ns	ns
Post mortem carcass condemnation	ns	ns	ns	ns	nd
Osteomyelitis	ns	< 0.05	ns	< 0.001	nd
Pleurisy/pneumonia	ns	ns	ns	ns	nd
Abscesses	ns	ns	ns	ns	nd
Melanosis	< 0.05	ns	< 0.05	ns	nd
Granulomatous lymphadenitis	ns	< 0.001	ns	< 0.001	nd
Erisipela	ns	ns	ns	ns	nd
Caquexia	ns	ns	ns	ns	nd
Pale soft and exudative meat	ns	ns	ns	ns	nd
Bloody meat	ns	ns	ns	ns	nd
Muscular necrosis	ns	ns	ns	ns	nd
Purulent nefritis	ns	ns	ns	ns	nd
Purulent metritis	ns	ns	ns	ns	nd
Jaundice	ns	ns	ns	ns	nd
Febrile meat	ns	ns	ns	ns	nd
Peritonitis	ns	ns	ns	ns	nd

FCI = food chain information form, DC = compulsory driver certification, ns = not significant, nd = not determined

(OR = 3.30; CI 95%: 2.33–4.67) and before 2009, during the time when the FCIf was not compulsory (OR = 2.10; CI 95%: 1.44–3.08).

According to the records, the main causes of carcass condemnations (Table 1) were osteomyelitis (38.5%), granulomatous lymphadenitis (22.7%) and pleurisy/pneumonia (21.2%). The factors related to both *ante mortem* and *post mortem* condemnations are shown in Table 2. The month of January was associated with higher *ante mortem* rejections ($P < 0.01$) and deaths during transportation ($P < 0.01$).

In contrast, deaths in pens ($P > 0.05$) were not influenced by month. A reduction of deaths during transportation ($P < 0.05$) was associated with the compulsory certification of drivers/transporters.

There was a seasonal association with the total *ante mortem* rejections ($P < 0.05$) and also with deaths in pens ($P < 0.01$) during winter for both cases. In the univariate analysis, the odds of *ante mortem* rejections (OR = 1.85; CI 95%: 1.32–2.59) and deaths in pens (OR = 1.62; CI 95%: 1.02–2.57) were also higher in the cold season. Moreover, the compulsory certification of pig drivers/transporters was associated with a decrease in the *ante mortem* ($P < 0.01$) rejections and deaths during transportation ($P < 0.01$)

Month ($P < 0.05$) and season ($P < 0.05$) influenced the cases of melanosis condemnations which were higher in December and autumn, respectively.

Records pertaining to *post mortem* carcass condemnations showed that osteomyelitis ($P < 0.01$) and granulomatous lymphadenitis ($P < 0.001$) were both influenced by year and were higher in 2006 and 2010, respectively. In addition, condemnations due to osteomyelitis (OR = 0.23; CI 95%: 0.15–0.34) and because of granulomatous lymphadenitis (OR = 0.44; CI 95%: 0.27–0.72) were both lower during period 1 although the number of condemnations due to these two causes decreased ($P < 0.001$) after compulsory fulfilment of the FCIf.

With regards to osteomyelitis, the odds of condemnation were lower after the compulsory fulfilment of the FCIf (OR = 0.45; CI 95%: 0.29–0.69).

However, this official document did not influence ($P > 0.05$) the overall number of cases of pig carcass condemnations after *post mortem* meat inspection.

DISCUSSION

The literature regarding pig carcass condemnation at slaughterhouses is scarce (Martinez et al. 2007) and research on carcass condemnation has focused on other species (Ansari-Lari and Rezagholi 2007; Alton et al. 2010; Regassa et al. 2013). However, recent studies have reported the utilisation of carcass condemnation data as a predictive tool for swine diseases (Thomas-Bachli et al. 2012, 2014). To our knowledge, this is the first report on pig carcass condemnation in Portugal.

Ante mortem and *post mortem* meat inspection is an important tool for controlling and guaranteeing food safety and consumer health and also for studying the prevalence and incidence of animal diseases (Gracey et al. 1999). Moreover, records from condemnations can be used by farmers to improve the management of the farm, thereby reducing the number of condemnations and increasing productivity.

The results of our analysis show that *post mortem* condemnations were higher than *ante mortem* condemnations and lower than observed by Martinez et al. (2007). These results can be explained by the fact that several *post mortem* findings are asymptomatic in live animals.

The progressive reduction in *ante mortem* rejections was associated with a decrease in deaths during transportation. This finding may be explained by the compulsory improvement in animal welfare measures during transportation (dalla Costa et al. 2007), by the improvement in the design and certification of animal transportation vehicles by the national veterinary authorities and by the compulsory certification of drivers (Regulation (EC) 1/2005). Moreover, deaths during transport were not influenced by season as observed by Gonsalvez et al. (2006). Although it has previously been reported that deaths during transportation are usually higher in hot climatic conditions (Smith and Allen 1976), our study showed an increase in January ($P < 0.01$) in accordance with Guardia et al. (1996).

However, the reduction in stress related with transportation was not reflected in the number of deaths in pens since these values were consistent throughout the study period, with an increase during the winter, mainly in December. Interestingly, Gonsalvez et al. (2006) found that the highest mortality rates were recorded in winter. This highlights the intolerance of pigs to thermal stress (dalla Costa et al. 2007). Pigs housed at low temperatures tend to group in order to create a warmer microclimate that protects them from cold. This behaviour has been found to lead to an increase in fighting behaviours and climbing over one another to seek resting places within the pen (Lambooij and Engel 1991). As a consequence, the results regarding death in pens indicate the need for improving thermal conditions in holding pens.

In contrast to the observations pertaining to *ante mortem* rejections, the reasons for carcass condemnations did not show associations with season or month. Of the 15 causes of carcass condemnation (Table 1) osteomyelitis (38.5%), granulomatous lymphadenitis (22.7%), pleurisy/pneumonia (21.2%), abscesses (8.4%), peritonitis (2.6%) and generalised melanosis (1.8%) were most prevalent whereas the other causes account for under 1% of condemnations. Moreover, the causes of carcass condemnations were consistent with those observed by Martinez et al. (2007). Flesja and Ulvesaeter (1979) reported mange as the main cause of carcass condemnation although abscesses and peritonitis represented approximately 50% of condemnations, in comparison with our findings. Our study revealed a rate of carcass condemnation of approximately 0.24%, although Tiong and Bin (1989) reported rates of approximately 0.1% and observed pyaemia, arthritis, polyserositis, jaundice, cachexia and peritonitis as the main causes of carcass condemnation.

Variations in the causes and prevalence of carcass condemnations reported in different studies may be associated with the geographical area, climatological conditions, farm management and health herd status (Martinez et al. 2007).

Tail biting has been described as a predisposing factor for osteomyelitis in pigs (Walker and Bilkei 2006; Martinez et al. 2007; Heinonen et al. 2010). This behaviour had been largely studied as an indicator of reduced animal welfare although it may be influenced by several external and internal factors such as environment, feeding, housing, male-to-female ratio, genetics, sex or age (Schroder-Petersen et al. 2003; Brunberg et al. 2011). According to our study, the condemnations caused by osteomyelitis decreased after 2009. This finding may be explained by the new regulations related to swine welfare during transportation after 2008 that reduced the number of deaths during transportation resulting in an economic gain. Based on these facts, the introduction of several welfare measures by farmers to avoid economical losses may explain the decrease in osteomyelitis.

Mycobacterium avium complex (MAC) is considered to be the main cause of granulomatous lymphadenitis observed in slaughtered pigs during *post mortem* examination (Pavlik et al. 2003; Domingos et al. 2009; Miranda et al. 2011). Swine infections caused by MAC result in severe economic losses for producers and the agro-industry. Lesions usually develop in the lymph nodes of the head and/or the mesentery (Wilson 2005). The presence of these lesions and the isolation of the agent has been described by several authors (Cleveland-Nielsen et al. 2002;Domingos et al. 2009) The importance of granulomatous lymphadenitis control and its detection during meat inspection is a public health concern mainly for immunocompromised patients (Ristola et al. 1999).

Carcass condemnations due to osteomyelitis and granulomatous lymphadenitis were influenced both by year and the compulsory fulfilment of the FCIf. The improvement in animal welfare on farms over the last years may explain the decrease in condemnations due to osteomyelitis. However, the infection of pigs by agents belonging to the *Mycobacterium avium* Complex is probably environmental. Thus, the variations in the number of condemnations observed throughout the study period may be associated with region, climate or by the presence of hosts (Spicic et al. 2010).

The influence of the FCIf on the reductions in osteomyelitis and caseous lymphadenitis condemnations cannot be easily explained because the document does not include any information about disease prevalence and/or diagnostics at the farm level. In addition, the mandatory fulfilment of the FCIf was not associated with a decrease in overall carcass condemnations. Thus, the effects of the compulsory fulfilment of the FCIf as a measure to improve the transparency of food safety and animal health are not fully clear.

Melanosis is characterised by an abnormal accumulation of melanin pigments in various body locations (Perestrelo-Vieira et al. 2000; Mellau et al. 2010) and leads to carcass condemnation (Regulation (EC) 854/2004). In pigs, melanin pigment is usually present in black breeds or crossbreeds, and is located in the abdominal fat and/or mammary parenchyma of sows and even in the abdominal fat of boards. However, its presence has also been described in other locations, e.g. skin, lung or lymph nodes (Wilson et al. 2005; Teixeira et al. 2013). Generalised melanosis is associated with melanocytic tumours of genetic aetiology (Perestrelo-Vieira et al. 2000). Despite our observations of the influence of the season on melanosis condemnations, to our knowledge there are no reports on the seasonality of melanosis. The study carried out by Teixeira et al. (2013) in several Portuguese slaughterhouses showed that 30% of melanocytic lesions observed in pig carcasses intended for human consumption had tumour characteristics.

Records of condemnations due to pleurisy/pneumonia were not specified. While this condemnation category includes several conditions such pleuropneumonia, catarrhal bronchopneumonia or pleuritis, the latter has been referred to as the main cause of condemnation (Cleveland-Nielsen et al. 2002). In cases of carcass condemnation due to abscesses and peritonitis, no relationship between osteomyelitis and cachexia condemnation was recorded.

The study of carcass condemnation could be used as a control tool to verify the emergence, evolution and control of swine diseases. These data provide invaluable assistance to producers and veterinary authorities in their efforts to improve and adapt health programs and/or strategies according to the epidemiological context and to avoid economic losses. In addition, *ante mortem* and *post mortem* meat inspection by the OVI is still considered as an important step in the food chain and in the surveillance of welfare, diseases and zoonoses of swine as well as a guarantee of meat food safety (Codex Alimentarius 2005; OIE 2010). Thus, classical meat inspection has led to the detection of epidemiological diseases such as classical swine fever or foot and mouth disease after the failure of other epidemiological surveillance systems (EFSA 2011)

CONCLUSION

The study of pig carcass condemnations showed that *ante mortem* rejections were lower than *post mortem* rejections. With respect to *ante mortem* rejections, deaths during transportation were higher than deaths in pens. The improvement in animal welfare, both on farms and during transportation as well as the compulsory certification of vehicles and drivers have contributed to the reduction of deaths during transportation. However, the consistent number of death in pens observed throughout the study period, mainly in winter indicates a necessity of improving the climactic conditions of the holding area in slaughterhouses.

Over 80% of the total number of carcass condemnations were classified as pertaining to osteomyelitis, granulomatous lymphadenitis and pleurisy/pneumonia.

Osteomyelitis was associated with tail biting and this behaviour is related to animal stress on the farms. Thus, the improvement in animal welfare conditions at the farm level correlates with the progressive decrease in osteomyelitis condemnations.

The control of granulomatous lymphadenitis on farms is difficult due to its environmental nature and its control by meat inspection is fundamental in the control of its zoonotic potential.

The FCIf was implemented as a measure to improve the transparency of food safety and animal health in the food chain from farm to fork. However, its lack of influence in decreasing carcass condemnations indicates that its importance is dubious. The study of carcass condemnation could be used as a control tool to verify the emergence, evolution and control of swine diseases. These data could be used by producers and veterinary authorities to improve animal health, food safety and veterinary public health programs and/or strategies according to the epidemiological context.

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