Research in Veterinary Science 152 (2022) 72–82

Contents lists available at ScienceDirect

Research in Veterinary Science

journal homepage: www.elsevier.com/locate/rvsc

# A European survey on post-mortem inspection of finishing pigs: Total condemnation criteria to declare meat unfit for human consumption

Madalena Vieira-Pinto [a,*], Nina Langkabel [b], Susana Santos [c], Lis Alban [d,e], Jaime Gómez Laguna [f], Bojan Blagojevic [g], Diana Meemken [b], Silvia Bonardi [h], Boris Antunović [i], Sergio Ghidini [j], Patric Maurer [k], Ole Alvseike [l], Riikka Laukkanen-Ninios [m]

[a] Animal and Veterinary Research Center (CECAV), Associate Laboratory for Animal and Veterinary Sciences (AL4AnimalS), Department of Veterinary Science, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal
[b] Department of Veterinary Medicine, Freie Universität Berlin, Institute of Food Safety and Food Hygiene, Berlin, Germany
[c] Food Safety Unit, Public Health Division, General Directorate for Food and Veterinary, Lisbon, Portugal
[d] Danish Agriculture & Food Council, Copenhagen V, Denmark
[e] Department of Veterinary and Animal Sciences, University of Copenhagen, Denmark
[f] Department of Anatomy and Comparative Pathology and Toxicology, University of Córdoba, Spain
[g] Department of Veterinary Medicine, Faculty of Agriculture, University of Novi Sad, Serbia
[h] Department of Veterinary Science, University of Parma, Italy
[i] University of J.J. Strossmayer, Faculty of Agrobiotechnical Sciences, Croatia
[j] Department of Food and Drug, University of Parma, Italy
[k] Food Surveillance Unit, Ministry of Labour, Social Welfare, Women and Family Affairs of Thuringia, Germany
[l] Animalia – Norwegian Meat and Poultry Research Center, Oslo, Norway
[m] Department of Food Hygiene and Environmental Health, Faculty of Veterinary Medicine, University of Helsinki, Helsinki, Finland

ARTICLE INFO

*Keywords:*
Post-mortem meat inspection
Total condemnation criteria
Pig
Meat fitness

ABSTRACT

Meat inspection (MI) is essential to verify compliance with legal requirements related to human and animal health and animal welfare protections. Judgement criteria applied during MI, resulting in condemnation data of importance, among other things, for livestock producers and for benchmarking reasons. However, although the Meat Inspection Regulation sets out judgement criteria, most are generic, favouring flexibility, but also subjectivity.

To address the degree of variation on total condemnation (TC) criteria applied during post-mortem inspection (PMI) of finishing pigs, an online survey was prepared aiming to collect this information from several European countries. The focus was on TC criteria regarding the following PMI findings: abscesses, arthritis, cachexia, erysipelas, icterus, *Mycobacterium*-like lesions, osteomyelitis, peritonitis, pleuritis and pneumonia.

From September to November 2020, a total of 44 completed questionnaires were obtained from 26 European countries. The results showed a substantial variation in the TC criteria in place in the participating countries. One of the main reasons for the variability seen in the respondents' reported answers was related to the indicators used to define a generalised condition related to the 10 PMI findings addressed, making harmonisation a challenge and avoiding to draw conclusions when comparing condemnation causes between abattoirs.

This implies that it would make sense to look into how a generalised condition can be identified/described and how it should be judged.

The results should be used as inspiration towards possible harmonisation, improving decision-making, and permitting comparative analysis between different reports to allow trend analyses and benchmarking.

* Corresponding author.
*E-mail addresses:* mmvpinto@utad.pt (M. Vieira-Pinto), nina.langkabel@fu-berlin.de (N. Langkabel), ssantos@dgav.pt (S. Santos), lia@lf.dk (L. Alban), j.gomez-laguna@uco.es (J.G. Laguna), diana.meemken@fu-berlin.de (D. Meemken), silvia.bonardi@unipr.it (S. Bonardi), boris.antunovic@fazos.hr (B. Antunović), sergio.ghidini@unipr.it (S. Ghidini), Patric.Maurer@tmasgff.thueringen.de (P. Maurer), ole.alvseike@animalia.no (O. Alvseike), riikka.laukkanen-ninios@helsinki.fi (R. Laukkanen-Ninios).

https://doi.org/10.1016/j.rvsc.2022.07.013
Received 3 April 2022; Received in revised form 12 June 2022; Accepted 18 July 2022
Available online 21 July 2022

## 1. Introduction

Meat-producing animals must undergo meat inspection at the abattoir before their meat can be placed on the market for human consumption (Collins and Huey, 2015). Meat inspection is essential to verify compliance with the requirements on human and animal health and animal welfare (Commission Implementing Regulation (EU) 2019/627). Also, control of animal by-products and protection of the environment are tasks performed during meat inspection. For this reason, it is considered that meat inspection includes broad objectives that fall under the One Health approach (Guardone et al., 2020).

Meat inspection is part of official controls that currently, in European member states, are regulated by Commission Implementing Regulation (EU) 2019/627. The main tasks of meat inspection consist of checking food chain information (FCI), ante-mortem inspection of live animals, post-mortem inspection of carcasses and viscera involving visual inspection, palpation, and incision of particular organs, and lymph nodes, and, if necessary, additional laboratory tests. Although at the time they were introduced, traditional meat inspection procedures were effective to detect classic zoonoses like brucellosis, tuberculosis and cysticercosis (Edwards et al., 1997), these and other infections may no longer be relevant in a country, region or animal species (Alban et al., 2021). However, post-mortem meat inspection (PMI) remains an invaluable contribution to the assessment of animal health through the detection of lesions on carcasses and viscera of slaughtered animals (Harley et al., 2012; OIE, 2021). This highlights PMI as an important source of data for the control of issues affecting human and animal health as well as animal welfare (Alban et al., 2021; Correia-Gomes et al., 2016; Guardone et al., 2020; Harley et al., 2012; Scollo et al., 2017; Stärk et al., 2014). Overall, meat inspection is considered one of the most broadly applied and oldest surveillance systems (Stärk et al., 2014), and it is without doubt the critical and most efficient point of surveillance for animal diseases in the pork value chain (Collins and Huey, 2015).

For each finding detected during PMI, condemnation criteria are applied in order to remove meat unfit for human consumption from further processing. From this activity, lists of reasons for condemnations are created, being useful for monitoring animal health (Collins and Huey, 2015). Also, these data have the potential to be used for demonstration of trends and variations in animal disease incidence due to husbandry methods, epidemiological factors and prophylactic protocols, as well as being a means to measure, benchmark and improve animal health at farm level (Collins and Huey, 2015). Therefore, to benefit from the full potential of these databases, they need to be comparable between abattoirs, regions and countries, and to this end, similar condemnation criteria need to be applied.

Article 45 of Commission Implementing Regulation (EU) 2019/627 sets out 20 judgement criteria, applicable for finishing pigs, to declare fresh meat unfit for human consumption in all Member States. Among these, only five refer to deviations detectable during PMI, and even these are not specific criteria (e.g. one judgement criterion is parasitic infestation, pathological or organoleptic alterations). For this reason, differences in interpretation can occur, as the criteria favour flexibility but also subjectivity in their application by the Official Veterinarian (OV) during PMI.

Therefore, the objective of this study was to map European post-mortem condemnation criteria and their application to declare meat unfit for human consumption regarding important post-mortem findings in finishing pigs. By publishing this information, we expect to share the knowledge/experiences of experts in the field, which could be used to elucidate the different approaches regarding judgement criteria in place. Also, we aim to draw general conclusions relevant for PMI's total condemnation (TC) criteria that could be used as inspiration towards possible harmonisation of these criteria.

## 2. Materials and methods

This work is part of a questionnaire study by COST Action 18,105 (RIBMINS), aiming to collect information on how PMI of finishing pigs is currently performed in Europe.

An online survey using an in-depth questionnaire was prepared using SurveyHero® (enuvoGmbH, Zurich, Switzerland). The questionnaire included open and multiple-choice questions regarding the background information of the respondent and TC criteria the respondent uses during PMI of finishing pigs. The TC criteria asked about were targeted at 10 important gross pathological findings that can lead to TC and that can be detected during PMI of finishing pigs. These 10 PMI findings were selected based on internal discussions of RIBMINS members, representing Denmark, Finland, Germany, Italy, Norway, Portugal and Spain, who each provided information about the condemnation causes reported in 2019 in their country. The data covered finishing pigs, slaughtered and inspected in 2019, and mainly raised indoors. The 10 selected findings that can lead to TC were: Abscesses, arthritis, cachexia, erysipelas, icterus, *Mycobacterium*-like lesions, osteomyelitis, peritonitis, pleuritis and pneumonia.

As the survey was focused on TC criteria to declare meat unfit for human consumption (mostly qualitative data), the questionnaire was necessarily structured from different question types and also needed to enable free comments. Such an approach produces numerical results where these are possible, and it also benefits from qualitative estimation of prevailing answers by respondents from the enabled free comments. First, the respondent was asked about their country and years of experience in pig PMI. Afterwards, questions were asked regarding the use of the TC criteria ("in all cases" vs. "only in cases of generalised disease") regarding the 10 selected gross pathological findings at the time of slaughter. The group of respondents who answered "only in cases of generalised disease" was additionally asked to select the judgement criteria (JC) used for generalised disease, namely $JC_1$: Only choose as an option our definition of generic PMI findings indicators of generalised disease (GIGD); $JC_2$: Choose as an option "other PMI findings indicators" plus our definition of GIGD, and; $JC_3$: Only choose as an option "other PMI findings indicators" as suggestive of a generalised disease. The definition of GIGD within the $JC_1$ and $JC_2$ was offered by the authors of the current paper, after discussion and based on their own experiences. GIGD included: congestive carcass and/or organs, petechia and/or ecchymosis in different organs, and/or several reactive lymph nodes (Lnn.). Finally, the respondents who selected $JC_2$ and $JC_3$ options were able to describe the other PMI findings used as suggestive of generalised disease.

A pre-test of the draft of the questionnaire was given to 10 OVs with relevant experience in pig meat inspection, from five countries (Portugal, Italy, Finland, Germany and Denmark), to assess the level of understanding of the questions and detect any missing relevant information. Based on the answers, the survey was validated with minor modifications (Fig. 1). This final version was sent out in September 2020 via the RIBMINS national contact points and members of the European Commission's Expert Group on food hygiene and control of food of animal origin. At least one OV from each participating country was requested to answer.

The form was anonymous, and no personal data were requested as defined in Regulation (EU) 2016/679 for personal data protection.

## 3. Results and discussion

Responses from 44 OVs were obtained. The median duration of work experience in pig meat inspection was 10 years, ranging from 1 to 34 years. The responses came from 26 European countries (one to three responses from each country), as summarised in Table 1.

The responses obtained were from a wide subset of European countries, reflecting well the area's geographical, jurisdictional, cultural, scales of pig production and economic variations. The responding

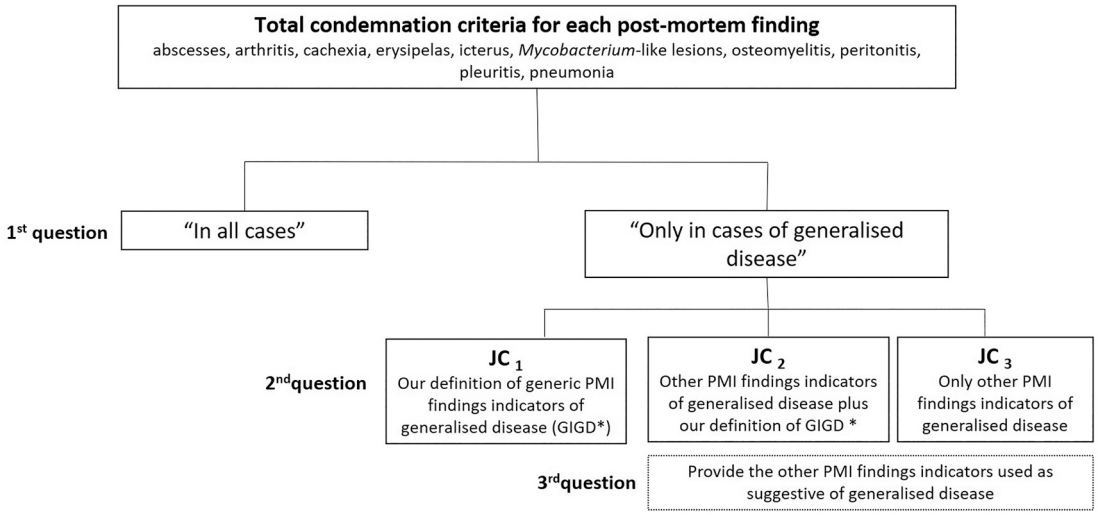


**Fig. 1.** Summary scheme of the answers addressed in the questionnaire.
JC: Judgement criteria; $JC_1$: Only choose as an option our definition of generic PMI findings indicators of generalised disease (GIGD); $JC_2$: Choose as an option "other PMI findings indicators" plus our definition of GIGD; $JC_3$: Only choose as an option "other PMI findings indicators" as suggestive of a generalised disease; GIDG included: congestive carcass and/or organs, petechia and/or ecchymosis in different organs, and/or several reactive lymph nodes.

**Table 1**
Description of country origin given by the 44 respondents to the questionnaire.

| Group | Number of responses | Number of countries | Countries |
|---|---|---|---|
| EU member states | 34 | 20 | Austria, Belgium, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden |
| Other | 10 | 6 | Albania, Iceland, Norway, Serbia, Switzerland, United Kingdom |
| Total | 44 | 26 | |

countries produce 79% of European pork, but the responses in our survey results were not weighted for volume. Also, respondent-dependent selection bias must be considered due to the few responses per country.

### 3.1. Total condemnation criteria: all cases vs. generalised disease

For the total number of answers ($N = 400$), considerable variation regarding the TC criteria used by OVs was revealed (Table 2), which is in agreement with findings described by Arzoomand et al. (2019).

The TC criterion "only in cases of generalised disease" (OGD) was used more often by the respondents than the criterion "in all cases" (AC) (72.7% versus 27.3%) (Table 2), which stresses the importance of achieving consensus about the definition of a "generalised condition" macroscopically detectable during PMI of finishing pigs. The greatest variability in the use of these two criteria was found for erysipelas and icterus cases (Table 2), that are, in some European countries like Spain (Alban et al., 2022) and Italy (Alban et al., 2022; Guardone et al., 2020), important causes of TC of pig carcasses.

Of all the theoretical cases where TC was decided only in cases of generalised disease ($n = 291$), our $JC_1$ option was found relevant by respondents in 144 theoretical cases (49.5%), while in 62 theoretical cases (21.3%), respondents applied additional judgement criteria ($JC_2$), and in 85 theoretical cases (29.2%), respondents applied their own criteria of generalised disease ($JC_3$). The distribution of applied judgement criteria options for each of the ten selected pathological findings are given in Table 2.

From the total number of answers, 70.8% (206: 144 $JC_1$ + 62 $JC_2$) of respondents used our definition of generic PMI findings of generalised

**Table 2**
Distribution of answers regarding the use of the TC criteria for each of 10 important PMI findings ($N = 400$).

| PMI findings | Number (%) of answers for TC judgement | | | | | |
|---|---|---|---|---|---|---|
| | In all Cases | Only in cases of generalised disease | | | | Total |
| | | $JC_1$ | $JC_2$ | $JC_3$ | Total | |
| Abscesses | 1 (2.4%) | 26 (65.0%) | 11 (27.5%) | 3 (7.5%) | 40 (97.6%) | 41 |
| Arthritis | 1 (2.5%) | 19 (48.7%) | 11 (28.2%) | 9 (23.1%) | 39 (97.5%) | 40 |
| Cachexia | 33 (80.5%) | 6 (75.0%) | 0 (0.0%) | 2 (25.0%) | 8 (19.5%) | 41 |
| Erysipelas | 24 (54.8%) | 11 (57.9%) | 5 (26.3%) | 3 (15.8%) | 19 (44.2%) | 43 |
| Icterus | 27 (62.8%) | 8 (50.0%) | 3 (18.8%) | 5 (31.3%) | 16 (37.2%) | 43 |
| *Mycobacterium*-like lesions | 6 (15.8%) | 20 (62.5%) | 7 (21.9%) | 5 (15.6%) | 32 (84.2%) | 38 |
| Osteomyelitis | 9 (22.5%) | 12 (38.7%) | 7 (22.6%) | 12 (38.7%) | 31 (77.5%) | 40 |
| Peritonitis | 6 (15.4%) | 13 (39.4%) | 10 (30.3%) | 10 (30.3%) | 33 (84.6%) | 39 |
| Pleuritis | 2 (5.4%) | 14 (40.0%) | 3 (8.6%) | 18 (51.4%) | 35 (94.6%) | 37 |
| Pneumonia | 0 (0.0%) | 15 (39.5%) | 5 (13.2%) | 18 (51.4%) | 38 (100%) | 38 |
| Total | 109 | 144 | 62 | 85 | 291 | 400 |

PMI: Post-mortem findings; TC: Total Condemnation; JC: Judgement criteria; $JC_1$: Only choose as an option our definition of generic PMI findings indicators of generalised disease (GIGD); $JC_2$: Choose as an option "other PMI findings indicators" plus our definition of GIGD; $JC_3$: Only choose as an option "other PMI findings indicators" as suggestive of a generalised disease; GIDG included: congestive carcass and/or organs, petechia and/or ecchymosis in different organs, and/or several reactive lymph nodes.

disease: "congestive carcass and/or organs, petechial and/or ecchymosis in different organs, and/or several reactive lymph nodes". Similar definitions can be seen in Collins and Huey (2015), Jensen et al. (2017), and Lindén et al. (2014). This answer was mainly chosen for abscesses, arthritis and *Mycobacterium*-like lesions, as opposed to pneumonia and pleuritis, where the majority choice was to use " other PMI findings indicators" as suggestive of a generalised disease" ($JC_3$) (Table 2, Fig. 2) (See in detail Section 3.2).

As aforementioned, generalised disease is one of the criteria defined in Article 45 of Commission Implementing Regulation (EU) 2019/627, but its related lesions are not explained.

Given the lack of details in the legislation, and given the large number of respondents who actively chose our definition of generalised disease, we suggest it could be used in the future as a generic definition for this TC criterion. Our TC criterion could be especially suitable for the three post-mortem findings for which respondents mostly chose this criterion (abscesses, arthritis and *Mycobacterium*-like lesions).

### 3.2. Condemnation criteria per each post-mortem finding

#### 3.2.1. Abscesses

Abscesses are one of the most common PMI finding routinely encountered in finishing pigs during PMI (Alban et al., 2022; Collins and Huey, 2015).

From the 41 respondents' answers related to abscesses (Table 2), only one chose the TC criterion "in all cases". This result is very coherent since abscesses per se should not be considered a cause of TC in all circumstances, and several issues should be considered in deciding if they should lead to TC or not.

From the remaining 40 respondents who chose the option of TC "only in cases of generalised disease", 65% (26), 27.5% (11) and 7.5% (3) chose $JC_1$, $JC_2$ and $JC_3$, respectively (Table 2). Ten out of 14 respondents who specified the use of other PMI findings indicators suggestive of a generalised disease related to abscesses provided more details (Table 3), referring to multiple abscesses (4), acute stage of abscesses (3) and involvement of lymph nodes (3).

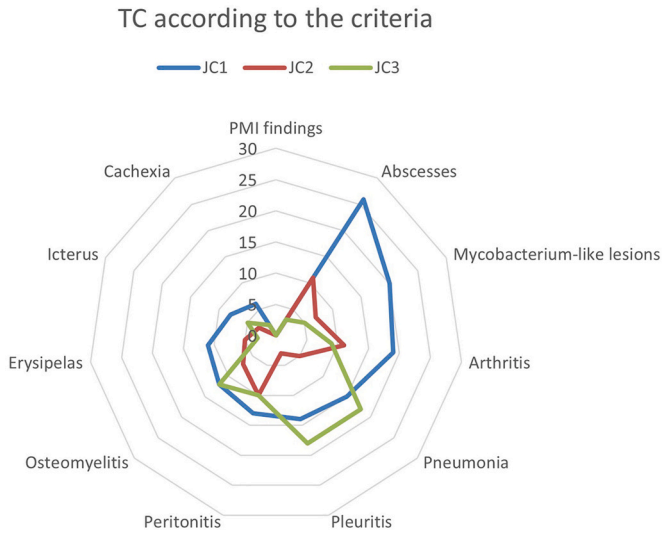


**Fig. 2.** Prevalence of the three judgement criteria (JC) for total condemnation (TC) within the group of answers "only in cases of generalised disease" in relation to the 10 PMI findings assessed.
PMI: Post-mortem inspection; TC: Total condemnation; JC: Judgement criteria; $JC_1$: Only choose as an option our definition of generic PMI findings indicators of generalised disease (GIGD); $JC_2$: Choose as an option "other PMI findings indicators" plus our definition of GIGD; $JC_3$: Only choose as an option "other PMI findings indicators" as suggestive of a generalised disease; GIDG included: congestive carcass and/or organs, petechia and/or ecchymosis in different organs, and/or several reactive lymph nodes.

**Table 3**
Other PMI findings indicating a generalised disease related to abscesses provided by 10 respondents.

| PMI findings indicating generalised disease related to pneumonia | Number of answers |
|---|---|
| Multiple abscesses | 4 |
| Multiple, other, or several | 3 |
| Multiple abscesses in a region with reactive lymph nodes | 1 |
| Acute abscesses | 3 |
| Acute stage of pyaemic abscesses | 1 |
| Acute abscesses in the lungs in combination with tail bites | 1 |
| Acute abscesses associated with tail bite (origin of infection) | 1 |
| Involvement of lymph nodes | 3 |
| Reactive lymph nodes | 1 |
| Lymphadenitis associated with tail bites | 1 |
| Purulent lymphadenitis | 1 |
| Total | 10[a] |

[a] Each respondent was able to provide more than one PMI findings indicator separately or together, so the total number of indicators is higher than the number of respondents.

The lymph node involvement was described by one respondent as the detection of "reactive lymph nodes". Since this is considered a generic alteration that fits all post-mortem findings related to inflammatory or infectious processes, it was included in our definition of GIGD that leads to TC. The other two respondents each gave a more specific answer, namely: lymphadenitis associated with tail biting, and purulent lymphadenitis.

Multiple abscesses were specified by four respondents (three described this condition as the only PMI finding indicator, while one respondent associated this condition with reactive lymph nodes). According to Collins and Huey (2015), after careful examination of the rest of the carcass and the viscera, condemnation of the affected part is usually sufficient for an abscess at a single site. In addition, Jensen et al. (2017) suggest that if abscesses are present in organs (e.g., spleen, brain or heart) that do not have direct access to the surroundings, the presence of even one single abscess should be indicative of pyaemia. According to these authors, both the location of the abscesses and the port of entry are to be evaluated, and the OV must ascertain if purulent foci have occurred because of generalised haematogenous spread (pyaemic condition). In cases with no signs of generalised disease, only local condemnation is indicated (Collins and Huey, 2015). In an opposite approach, in cases of the concomitant occurrence of tail lesions and suppurative lesions in lungs or peritoneum that have resulted due to spread via the bloodstream, TC should be applied (Collins and Huey, 2015; Jensen et al., 2017). This concept was addressed by two respondents who answered that lesional indicators of generalised disease were "acute abscesses in the lungs in combination with tail bites" and "acute abscesses with tail bite (infection origin)" (Table 3).

Respondents also introduced the stage (acute/chronic) of an abscess as another trait to be evaluated. In fact, if an abscess is in the acute stage of development (poor capsule formation, with fluid exudate, accompanied by systemic changes), it is very probable that pyogenic bacteria are in the bloodstream (Collins and Huey, 2015). The dating of the pathological findings is crucial, because old abscesses can be a result of septicaemia occurring at an earlier stage in life (Alban et al., 2021). Following Bækbo et al. (2016), an overall assessment should be made in suspicious chronic cases with dissemination of multiple abscesses.

Furthermore, the distribution of abscesses in the viscera is essential for macroscopic clarification of haematogenous spread, which is assessed by their random dissemination in the organs (Jensen et al., 2017). Since different combinations of additional lesional indicators can be observed, considerations always depend on the individual case (Jensen et al., 2017).

Summarising all the information provided by the respondents, the following lesional indicators related to abscesses are indicative of a

generalised disease stage at the time of slaughter, in addition to those included in our definition of GLGD: multiple and acute phase of abscesses, anatomical separation between the port of entry and abscess location and, in the case of organs, random distribution of the abscesses.

This information could be used as a reflexion on the the criteria described for abscesses in Codex Alimentarius (1993) recommending TC in cases of multiple pulmonary abscesses, embolic abscesses of the liver associated with recent umbilical infections, traumatic abscesses in the spleen, etc., and brain abscesses resulting from pyaemia.

### 3.2.2. Arthritis

Arthritis is defined as an inflammation of articular cartilage that can lead to swollen joints observed during PMI (Thompson, 2006).

Only one of the 40 respondents chose the TC criterion "in all cases" for arthritis (Table 2). From the remaining 39 who chose the option of TC "only in cases of generalised disease", most chose our definition of GIGD as the criterion for TC of the carcasses, which is in line with several authors (Collins and Huey, 2015; Jensen et al., 2017; Wilson, 2005) and with Codex Alimentarius (1993).

From the 20 respondents who specified the use of other PMI findings indicators suggestive of a generalised disease related to arthritis, 17 provided more details (Table 4). Generally, multiple arthritis (8), acute arthritis (5), wasting carcasses (4), and presence of abscesses and endocarditis (3) were the "other PMI findings criteria" provided by these respondents.

Regarding "multiple arthritis", five respondents did not specify any other characteristics, while one specified the number of joints involved (3 to 4). Surprisingly, another respondent specified "multiple arthritis associated with pulmonary pathology" without mentioning any other relevant anatomical structures concomitantly affected with the joints in pigs, such as serosa (Glässer's disease) or endocardium (erysipelas) (Wilson, 2005).

Concomitant endocarditis and abscesses were selected by three respondents, underlining the importance of *Erysipelothrix rhusiopathiae* infection as causative of arthritis. According to Jensen et al. (2017), Lindén et al. (2014) and Wilson (2005), pigs with arthritis caused by this microorganism have a typically pronounced hyperplasia of the synovial membrane. However, these features can also be present in other, non-zoonotic chronic arthritis conditions (e.g., that caused by *Mycoplasma* spp.) with different TC criteria, so a differential diagnosis is advisable.

**Table 4**
Other PMI findings indicating a generalised disease related to arthritis provided by 17 respondents.

| PMI findings indicating generalised disease related to arthritis | Number of answers |
|---|---|
| Multiple arthritis | 8 |
| Multiple joints infected/involved or polyarthritis | 5 |
| Several joints with chronic arthritis | 1 |
| Arthritis in 3–4 joints | 1 |
| Multiple arthritis associated with pulmonary pathology | 1 |
| Acute arthritis | 5 |
| Acute state | 1 |
| Acute infectious arthritis – purulent exudate | 1 |
| Presence of red or purulent exudate inside the joints | 1 |
| Wasting carcasses | 4 |
| Loss of weight or skinny pigs | 4 |
| Presence of abscesses and endocarditis | 3 |
| Nonspecific answers | 2 |
| Ante-mortem appearance (lameness), general condition of animal, number of joints involved, colour of joint fluid | 1 |
| Severity of the lesion (if it is opened), the chronicity, if other joints are affected, emaciation, decubitus, skin alterations, other organ affections. If polyarthritis is present, *Salmonella* should not be forgotten in this context | 1 |
| Total | 22[a] |

[a] Each respondent was able to provide more than one lesional indicator separately or together, so the total number of indicators is higher than the number of respondents.

As PMI finding indicators of generalised disease, one respondent mentioned "several joints with chronic arthritis", while five defined "acute arthritis", pointing out the importance of arthritis' duration (acute/chronic) (Weisbrode, 2007). Indeed, apart from the chronicity, it is necessary to assess if the arthritis is infectious or not, as this criterion can influence the final judgement. According to Jensen et al. (2017), aseptic joint inflammation has local significance only and, therefore, partial condemnation may suffice. In that case, lymph nodes will normally not be affected. In contrast, infectious acute arthritis must lead to TC. Moreover, chronic arthritis may only require partial condemnation of the affected parts and associated lymph nodes (Codex Alimentarius, 1993; Collins and Huey, 2015; Jensen et al., 2017). In addition, Collins and Huey (2015) specified the pathoanatomical indications for partial condemnation due to arthritis, based on the involvement of the regional lymph nodes, as follows: "The hind limb should be condemned if there is iliac, prescapular or prepectoral lymph node involvement. If three or more limbs show lymphatic involvement, the carcass warrants rejection. If the popliteal lymph node is enlarged but the iliac lymph nodes are normal, it may be sufficient to reject only the lower part of the hind limb."

Secondary osteomyelitis caused by the erosion of joint cartilage and the infection of surrounding tissues may also be seen, especially in case of suppurative arthritis and some cases of chronic infection (Lindén et al., 2014). Nevertheless, chronic arthritis may also be simply related to degenerative processes of the joint with no infection of surrounding tissues (Weisbrode, 2007). All these macroscopic characteristics due to arthritis can be observed in multiple combinations during PMI of finishing pigs, and all of them are important for the final judgement.

Also, according to Lindén et al. (2014), microorganisms can reach the joints by the haematogenous route (e.g., after tail biting), by extension of an inflammatory focus (in the adjacent soft tissues or bones) or through a penetrating wound. Therefore, during PMI, the source of arthritis should be identified to properly assess the potential spread of microorganisms and make the final judgement.

Another criterion associated with arthritis and presented by four respondents was "wasting carcass", previously cited as a valid reason for TC (Wilson, 2005).

Based on the above, to totally condemn arthritis cases due to generalised disease, multiple arthritis, acute arthritis or a wasting carcass should be observed. This information could be used to be used as a reflexion on the Codex Alimentarius (1993) recommendation that only indicates TC in cases of acute (fibrinous, purulent) infectious arthritis, e.g., polyarthritis in new-born animals, unless approved by laboratory test results. However, the use of laboratory testing was not mentioned by any of our respondents.

### 3.2.3. Cachexia

Extreme emaciation, characterised by fatty tissue atrophy added to atrophy of other organs, such as muscles and liver, and shrunken lymph nodes, is traditionally called cachexia. Serous atrophy of bone marrow fat appears as a red, wet, slimy, gelatinous mass (Jensen et al., 2017; Lindén et al., 2014).

The 41 respondents' answers are shown in Table 2. Two respondents specified the use of other lesional indicators suggestive of generalised disease but did not provide more details.

The majority (33, 80.5%) of the answers (TC "in all cases") were in accordance with Commission Implementing Regulation (EU) 2019/627 that defines emaciation as a criterion to declare fresh meat unfit for human consumption. Since cachexia is the extreme phase of emaciation, TC is inevitable because of unacceptable organoleptic deviations from normal meat and because infective causes cannot be excluded.

Although legislation is clear regarding this criterion, the assessment of the animal's nutritional state to distinguish between thinness and emaciation may not be an easy task (Jensen et al., 2017). Both conditions, especially when not associated with concurrent disease, are

among the most difficult to assess during PMI (Collins and Huey, 2015).

In thin animals, there is a marked scarcity of fat, which is typically localised in the orbital region, around the large joints, around the coronary vessels of the heart and in the subserous tissue (Jensen et al., 2017; Wilson, 2005). This fatty tissue commonly has a normal texture (Jensen et al., 2017). Flesh is generally darker in colour and its surface is firm and dry on the cut. If the carcass is hung for some time, the surface becomes very dry and dark (Wilson, 2005). Emaciation, on the contrary, is a pathological condition, with wasting of muscular tissue and a reduced amount of fat tissue which has an abnormal appearance, being oedematous, jelly-like in consistency and sickly yellowish in colour (serous fatty atrophy) (Collins and Huey, 2015; Jensen et al., 2017; Lindén et al., 2014; Wilson, 2005). Emaciation typically occurs as a complication of chronic diseases but also because of malnutrition (Collins and Huey, 2015; Jensen et al., 2017). Both conditions should be carefully distinguished by the OV to identify non-compliance with sanitary and/or welfare rules. Where doubt exists, carcasses should be hung for 12–24 h to observe if they get wetter, which concomitantly leads to TC (Wilson, 2005).

#### 3.2.4. Erysipelas

Erysipelas in pigs is caused by *Erysipelothrix rhusiopathiae*. This disease has a worldwide distribution and great economic importance. Infected pigs are the main reservoir of the infection (Opriessnig and Coutinho, 2019; Wang et al., 2010). Disease in pigs occurs in acute, subacute and chronic forms. The acute form is mostly severe, characterised by sudden death of seemingly healthy animals or sometimes septicaemia accompanied by characteristic "diamond-shaped" skin lesions. The subacute form is less severe and is mainly characterised by skin lesions. The chronic form of pig erysipelas is mainly characterised by arthritis and endocarditis (Lindén et al., 2014; Wang et al., 2010).

From the 43 respondents' answers, 24 (55.8%) chose the TC criterion "in all cases" and 19 (44.2%) choose the option of TC "only in cases of generalised disease", which stresses the considerable divergence in the judgement criterion for this infection (Table 2). Non-harmonised criteria can be of extreme importance in countries like Spain (Alban et al., 2022) and Italy (Alban et al., 2022; Guardone et al., 2020), where erysipelas is one of the main causes of TC of pig carcasses.

Eight respondents reported the use of other PMI findings indicators suggestive of a generalised disease related to erysipelas. Skin (5), joint (4) and heart (2) lesions were the "other PMI findings criteria" provided by these respondents, pointing out the main topographic areas affected by erysipelas infection (Table 5) (Lindén et al., 2014; Wang et al., 2010).

**Table 5**
Other PMI findings indicating a generalised disease related to erysipelas provided by eight respondents.

| PMI findings indicating generalised disease related to erysipelas | Number of answers |
|---|---|
| Skin lesions | 5 |
| Acute cases with skin lesions | 3 |
| Ante-mortem observation of skin lesions combined with fever | 1 |
| Diffuse acute lesions with erythema | 1 |
| Joint lesions | 4 |
| Acute cases with joint lesions | 2 |
| Arthritis | 2 |
| Heart lesions | 2 |
| Endocarditis | 1 |
| Endocarditis with congested lymph nodes, petechiae, haemorrhages | 1 |
| Nonspecific answer | 1 |
| A bacteriological examination is possible to decide, whether it is local or generalised. If the altered region remains not local, with changes in the kidneys (petechial and nephritis forms), or other organs, lymph nodes or emaciation | 1 |
| Total | 12[a] |

[a] Each respondent was able to provide more than one PMI findings indicator separately or together, so the total number of indicators is higher than the number of respondents.

For most answers, the acute stage was mentioned by the respondents. Nevertheless, in three (two for arthritis and one for endocarditis) answers, no specification of acute/chronic status was described. According to several authors (Jensen et al., 2017; Wilson, 2005), TC should be required in acute cases, while in the chronic form, the judgement depends on how widespread the lesions are. If localised to some organs (i.e., heart, joint), these can be partially condemned, so not requiring TC. Therefore, acute/chronic, and local/generalised status are important criteria that should be adopted to judge if the slaughtered pig is fit for human consumption. However, the recommendation of Codex Alimentarius (1993) for erysipelas cases is stricter. In a brief way, it recommends that cases must be condemned as "fresh meat", although it is also possible, only after heat treatment, to commercialise meat from the chronic cases. This consideration about "heat treatment" was not seen at all in the answers given to our questionnaire, bringing the usefulness of this practice as a judgement criterion into question.

Regarding the zoonotic trait of this infection, erysipelas is considered an occupational disease that occurs mostly via contaminated cuts and skin abrasions in humans who work closely with infected pigs, their products (like meat) or wastes, i.e., farmers, abattoir personnel and veterinarians (Ninios, 2014). For these reasons, additional protection of these workers must be considered.

#### 3.2.5. Icterus

Icterus, or jaundice, is the accumulation of bile pigments, mainly bilirubin, mostly in elastin-containing tissue (Jensen et al., 2017). Icterus can be seen as yellow discolouration in pig carcasses. For the diagnosis of icterus, yellow pigmentation should be visible in other carcass parts than fat, since carotenoids from feed can also cause yellow pigmentation of fat (Collins and Huey, 2015; Herenda et al., 1994). However, cattle are more prone to carotenoid accumulation than pigs (Álvarez et al., 2015; Collins and Huey, 2015; Herenda et al., 1994).

Icterus was reported by several studies as an important cause of TC of slaughtered pigs (Alban et al., 2022; Canadian Food Inspection Agency, 2021; Guardone et al., 2020). The causes of icterus can be pre-hepatic (haemolysis), hepatic (liver injury) or post-hepatic (obstruction of bile ducts) (Herenda et al., 1994).

From the 43 answers related to icterus, 27 (62.8%) chose the TC criterion "in all cases" and 16 chose the option of TC "Only in cases of generalised disease" (Table 2), indicating a considerable divergence in the judgement criterion for this frequent condition (Alban et al., 2022; Guardone et al., 2020).

Of the 16 respondents who chose the TC option "only in cases of generalised disease", eight specified other PMI findings indicators for a generalised disease related to icterus. The majority of these ($n = 5$) stated that TC should be applied if the yellow colour persists in the carcass after 24 h refrigeration, since enzymes may remove the yellow colour (Collins and Huey, 2015; Herenda et al., 1994). If the pigmentation is only slightly evident on the re-examination, the carcass can be accepted for human consumption, but if not, TC must be applied according to Commission Implementing Regulation (EU) 2019/627 Article 45 (o): pathological or organoleptic changes. Jensen et al. (2017) draw attention to the fact that carcass judgement postponed for 24 h does not apply to icterus caused by hepatic insufficiency or toxic conditions. These two arguments related to icterus aetiology were also presented by four (liver pathology) and three (infectious or toxic) of our respondents, respectively.

All the criteria presented by our respondents are also included in the Codex Alimentarius that recommends TC of icterus cases when they are haemolytic, toxic or obstructive (severe and not disappearing within 24 h), physiological (e.g., neonates) icterus or due to fracture, torsion of spleen etc., if discolouration is distinct 24 h after slaughter (Codex Alimentarius, 1993).

### 3.2.6. *Mycobacterium*-like lesions

*Mycobacterium*-like lesions, also known as tuberculosis-like lesions (TBL), include all those lesions with gross characteristics like those caused by bacteria belonging to the genus *Mycobacterium*. Pigs are susceptible to mycobacteria belonging to *Mycobacterium tuberculosis* complex (MTC) as well as to *Mycobacterium avium* complex (MAC), with *M. bovis* and *M. avium hominissuis* as the most representative mycobacteria from each group, respectively (Robbe-Austerman and Thoen, 2019). Infection with *M. bovis* is mainly restricted to tuberculosis-endemic countries and to outdoor or free-range pigs (Cardoso-Toset et al., 2015a; Robbe-Austerman and Thoen, 2019). *Mycobacterium*-like lesions are usually limited in pigs to head and mesenteric lymph nodes, since both the respiratory and digestive routes of infection play an important role (Cardoso-Toset et al., 2015a).

Although gross distinction between lesions caused by MTC and MAC is difficult, some general remarks can be considered. MTC lesions are usually paucibacillary, well demarcated, with several foci of mineralisation according to the stage of the infection and easily enucleated. MAC lesions are also paucibacillary, but show a more "diffuse" picture, with poor demarcation, random mineralisation and a neoplastic appearance (Robbe-Austerman and Thoen, 2019). Although several factors need to be considered, mycobacteria belonging to MTC tend to cause generalised disease more easily than those belonging to MAC. The generalised disease is usually observed when the host response fails to retain the mycobacteria at the point of entry, allowing them to invade the lymph haematic system and spread to other organs such as lung, liver or spleen.

From the 38 respondents' answers related to *Mycobacterium*-like lesions as a condemnation criterion, six (15.8%) respondents chose the TC criterion "in all cases", and the remaining 32 chose "only in cases of generalised disease" (Table 2). Twelve answers specified the use of other PMI findings indicators suggestive of a generalised disease related to *Mycobacterium*-like lesions. In a generic way, all respondents mentioned that TC should be applied if multiple lesions are present "in organs other than the *Lnn. mandibulares* and *mesenteriales* and the liver"; such other organs are the spleen, lungs and/or other lymph nodes, highlighting the distribution of the lesions in different anatomical locations.

Those respondents who chose the TC criterion "in all cases" could be justified in thinking of the zoonotic risk of mycobacteria. However, it is noteworthy that not all mycobacterial infections pose a zoonotic risk (those that do are mostly restricted to the MTC). Moreover, we stress, too, the difficulty of differentiating only by visual inspection *Mycobacterium*-like lesions from those caused by other pathogens, such as *Trueperella pyogenes* or *Streptococcus* spp., which may concomitantly appear in the same animal (Cardoso-Toset et al., 2015a). This issue emphasises the necessity of using better, adequate terminology to support the reality seen at the abattoir or to use supporting ancillary methods to determine a more accurate diagnosis.

The repertoire of answers regarding $JC_{1–3}$ evidences a kind of misunderstanding regarding the application of the term "generalisation". In our questionnaire, some respondents considered generalisation, as stated above, to occur when organs other than mandibular or mesenteric lymph nodes and the liver have *Mycobacterum*-like lesions or when such lesions are observed not only in mandibular lymph nodes. However, *Mycobacterium*-like lesions in either lymph nodes or liver may already be indicative of generalised disease. A further complication is that several lesions may be found in the head of a pig in locations besides the mandibular lymph nodes, such as in the tonsils or in the retropharyngeal lymph nodes, and the process can still be considered as localised.

It is also worthwhile remarking on the answer of one respondent who considered TC is required when the lesions are located in more than one organ with laboratory confirmation of *Mycobacterium* spp. Specifically, there are several difficulties in achieving proper diagnostic confirmation of *Mycobacterium* spp. lesions. Although ante-mortem techniques based on serology are commercially available for pigs (Cardoso-Toset et al., 2017) and are in use in one big slaughter company in Germany for example, they only evidence the previous exposure to mycobacteria but not the infection itself. On the other hand, microbiological culture of *Mycobacterium* spp. is time consuming and requires several weeks to obtain a final diagnosis. The best way currently to gain a rapid and direct diagnosis of *Mycobacterium*-like lesions in pigs is by performing quantitative real-time Polymerase Chain Reaction from fresh tissues (Cardoso-Toset et al., 2015b), although we note that to avoid false positive or negative results, intra-laboratory validation is required before utilising this option.

Our results are somewhat in agreement with Codex Alimentarius (1993), which recommends TC of pig carcasses in the case of extensive *Mycobacterium*-like lesions of lymph nodes or other affected organs. However, this description can be misinterpreted, and a more precise definition of generalised disease, including affection of different organs from different body cavities or systemic spread, should be considered instead of "extensive lesions".

### 3.2.7. *Osteomyelitis*

Osteomyelitis is an inflammation of the bone tissue with involvement of the bone marrow (Thompson, 2006). It is commonly caused by pyogenic bacteria (Lindén et al., 2014; Vieira-Pinto et al., 2020), so for this reason, systemic infection related to osteomyelitis is commonly called pyaemia, which means septicaemia due to generalised haematogenous spread of pyogenic bacteria (Jensen et al., 2017).

From the 40 respondents' answers related to osteomyelitis as a condemnation criterion, nine (22.5%) specified the TC criterion "in all cases" (Table 2). Total rejection of all carcasses detected with this condition may occur not only due to the traditional perception of the risk of osteomyelitis being related to pyaemia because of the high vascularisation of the bone marrow and its role in the production of blood cells, but also due to the disgusting visual look that these lesions may have (Vieira-Pinto et al., 2020).

From the remaining 31 answers from respondents who selected the TC option "only in cases of generalised disease", 18 gave additional information for "other PMI findings indicators", like presence of concomitant abscesses (9) and acute stage of osteomyelitis (9).

Abscesses were reported as the most common pyaemia-related lesions related to osteomyelitis (Vieira-Pinto et al., 2020). The presence of concomitant abscesses in different tissues, besides the bone, can be a sign of pyaemia (Lindén et al., 2014). Importantly, though, concomitant abscesses can be an additional cause of pyaemia, or can be a cause of osteomyelitis itself, as this lesion type can be a risk for developing pyaemia and, secondarily, abscesses. These secondary abscesses should not be confused with those resulting from osteomyelitis fistulation (bone necrosis with subsequent rupture of the periosteum and the extension of the infection to the adjacent tissue) that forms a "secondary dissecting abscess", as can be seen in the psoas muscle by fistulation of the lumbar vertebrae with osteomyelitis (Jensen et al., 2017; Pedersen et al., 2017; Vieira-Pinto et al., 2020). These facts signify it is of importance to evaluate, simultaneously, the location of the concomitant abscesses, osteomyelitis, and the port of entry, to ascertain macroscopically whether the abscesses have occurred because of generalised haematogenous spread (pyaemic condition). Concomitant abscesses in tissues not anatomically related to osteomyelitis point to haematogenous spread (Lindén et al., 2014).

The same approach should be adopted when no abscess is present. In these cases, the location of the osteomyelitis and its source of infection are analysed simultaneously to evaluate the possible types of bacterial spread (i.e., local or systemic) (Lindén et al., 2014). An example of this approach is the spread assessment in connection with tail lesions (Collins and Huey, 2015; Jensen et al., 2017). Here, an infection spreads from the pig tail to the pelvis via the local lymphatic system, from the tail to the ribs and limbs via the bloodstream or from the tail to the spinal vertebrae via the cerebrospinal fluid (Collins and Huey, 2015). It is considered that concomitant tail lesion and osteomyelitis in the bones surrounding up to and including the ileosacral joint is the result of local

spread via the lymphatic system and is, therefore, not an expression of a pyaemic condition (Collins and Huey, 2015; Jensen et al., 2017; Lindén et al., 2014), if no other signs of generalised disease are present. Also, if an abscess in the tail and one or more in contiguous spinal vertebrae are found, resulting from infection via cerebrospinal fluid, local condemnation of the tail and the spinal column may be sufficient. However, if vertebral osteomyelitis is present in two independent regions, this may be a signal of haematogenous spread of pyogenic microorganisms, and TC is recommended (Collins and Huey, 2015; Jensen et al., 2017). Also, in the presence of suppurative lesions in the tail and one or more in the ribs or forelegs, TC is justified (Collins and Huey, 2015; Lindén et al., 2014).

Nevertheless, it is necessary to be aware that osteomyelitis can present as a unique lesion observed in the carcass during PMI (Vieira-Pinto et al., 2020). Even regarding tail lesions, these may have already healed at the time of slaughter and, therefore, cannot be detected at PMI (Kruse et al., 2015). Especially in these single cases, classification of the lesion as acute or chronic is of major relevance. The acute stage was mentioned (9 respondents) as an PMI finding indicating generalised disease related to osteomyelitis. This is in accordance with Ninios (2014), who stated that acute single osteomyelitis may lead to TC, while chronic single lesions mainly lead to partial condemnation, because acute lesions are more related to generalised disease prior to slaughter (Collins and Huey, 2015; Jensen et al., 2017; Vieira-Pinto et al., 2020). According to Jensen et al. (2017), if osteomyelitis is not surrounded by a fibrous capsule, TC should be applied (However, during PMI it can be difficult to classify the stage of osteomyelitis correctly, although the proposal of Vieira-Pinto et al. (2020) can help.

Based on the above, to totally condemn osteomyelitis cases due to generalised disease, it is important to evaluate the presence of "concomitant abscesses" and their distribution, to assess whether indicate an "acute stage" and to establish the source of infection. This information could be used as a reflexion on the Codex Alimentarius recommendations that only require TC in cases of osteomyelitis when gangrenous, suppurative or when accompanied by metastasis (Codex Alimentarius, 1993).

For the remaining non-generalised cases, it would be possible to conduct an overall assessment to evaluate possible dissemination of purulent lesions not directly visible in the internal and external surface of the carcass (Bækbo et al., 2016; Vieira-Pinto et al., 2020).

### 3.2.8. Peritonitis

Inflammation of the peritoneum is called peritonitis, which can be caused by impregnation of microorganisms due to perforation of the peritoneum, haematogenous spread, lymphogenous spread or by direct invasion from an organ lesion in the adjacent tissues (Jensen et al., 2017). In slaughter animals, diffuse peritonitis is the most common form of peritonitis detected (Jensen et al., 2017). Peritonitis can also be characterised by the peritoneum adhering to the surface of the abdominal cavity or the organs within the abdominal cavity. It can often become septicaemic (Wilson, 2005).

From the 39 respondents' answers, six (15.4%) chose the TC criterion "in all cases". From the 33 who selected the TC option "only in cases of generalised disease", 16 provided more details, resulting in 26 answers with other PMI findings indicators of a generalised disease related to peritonitis (Table 6). The stages of acute (8) and diffuse (6) counted for 58% of the proposed indicators. According to Jensen et al. (2017), the decision as to whether acute peritonitis should lead to partial condemnation or TC depends on the distribution of the lesions. Local distribution of lesions should lead to partial condemnation whereas a diffuse distribution of the lesions should lead to TC. However, if a pig with acute peritonitis also has fever, TC is the only possible decision.

Peritonitis should lead to TC if evidence of systemic infection is present (Wilson, 2005), which was referred to as septicaemic peritonitis in two answers given by the respondents (Table 6).

Cases of less complicated chronic peritonitis (e.g., diffuse fibrous adhesive chronic peritonitis) necessitate partial condemnation, and cases of complicated chronic peritonitis necessitate TC (Jensen et al., 2017). Complications of peritonitis were specified in six answers as "peritonitis associated with other lesions or conditions", like "abscesses, endocarditis and other generalised lesions" or "enteritis, icterus, polyserositis" (Table 6). These examples show the multiplicity of lesions associated with peritonitis that can be included in the designation "complications of peritonitis" proposed by Jensen et al. (2017). In our opinion, the perspective described by Jensen et al. (2017) could be used as a reflexion on the Codex Alimentarius, which recommends TC only in situations of acute, diffuse or extensive peritonitis (Codex Alimentarius, 1993).

**Table 6**
Other PMI findings indicating a generalised disease related to peritonitis provided by 16 respondents.

| PMI findings indicating generalised disease related to peritonitis | Number of answers |
|---|---|
| Acute peritonitis | 8 |
| Acute status | 4 |
| Acute and generalised | 1 |
| Acute: purulent or fibrinous | 2 |
| Acute congestive | 1 |
| Diffuse peritonitis | 6 |
| Widespread, not local distribution, generalised, diffuse | 6 |
| Associated to other lesions or conditions | 6 |
| Stinking fluid in the abdomen | 1 |
| Abscesses, endocarditis, and other generalised lesions | 1 |
| Congested intestines with reactive lymph nodes | 1 |
| Pericarditis, metritis caused by bladder rupture | 1 |
| Other inflammatory lesions with reactive lymph nodes | 1 |
| Enteritis, icterus, polyserositis | 1 |
| Wasting carcasses | 4 |
| Septic peritonitis | 2 |
| Total | 26[a] |

[a] Each respondent was able to provide more than one PMI finding indicator separately or together, so the total number of indicators is higher than the number of respondents.

### 3.2.9. Pleuritis

An inflammation of the pleura is called pleuritis (synonymic: pleurisy) and is the most common lesion in the pleura of finishing pigs that can be found during PMI. Initially, hyperaemia and increased thickness of the pleura may occur, giving it a velvety reddish appearance (Collins and Huey, 2015). Subsequently, an exudate appears, which may remain serous, or become fibrinous or purulent. The various types of exudates may coexist, forming various types of pleuritis, such as fibrinous-haemorrhagic or fibrinous-purulent, among others (Lopez, 2001). In a chronic phase, pleuritis may be characterised by fibrosis, with possible adherences and chronic abscesses (Jensen et al., 2017). These adhesions may cause lung rupture during evisceration, leaving fragments of the lung adhered to the costal cavity of the carcass (Collins and Huey, 2015).

In most cases, pleuritis follows inflammation of other organs of the thorax, mostly the lung, but also the pericardium (Jensen et al., 2017). When associated with pneumonia, particularly fibrinous pneumonia, pleuritis cover the affected lung parenchyma (Lopez, 2001). This condition is called pleuropneumonia, as is the case for pleuropneumonia caused by *Actinobacillus pleuropneumoniae*, which has an almost pathognomonic localisation in the dorsal-caudal region of the lung (Vieira-Pinto et al., 2013).

However, pleuritis can also be part of a generalised condition like polyserositis or septicaemia (Jensen et al., 2017). In these cases, pleuritis presents as bilateral lesions, and is caused by agents spread via the bloodstream, like *Mycoplasma hyorhinis* or *Haemophilus parasuis* (Jensen et al., 2017; Vieira-Pinto et al., 2013).

From the 37 respondents' answers related to pleuritis, only two chose the TC criterion "in all cases", while the others chose "only in cases of generalised disease" (Table 2), and 15 chose the use of other PMI

findings indicators (Table 7). As with peritonitis, a high variability of PMI findings indicators(23) for generalisation of pleuritis-related disease was observed, with the acute stage presented in four responses and "extension" mentioned in two answers (Table 7). According to Jensen et al. (2017), both indicators (acute stage, and the extension of pleuritis) should be combined, so that in case of acute fibrinous, serofibrinous, suppurative or putrid pleuritis of more than 25% of the surface of the *pleura costalis* or the *pleura pulmonalis*, the decision should be TC. In the current study, this combination was presented in two answers, and one cited the same percentage (25%) of affected pleural surface (Table 7).

The type of pleuritis was a indicator described in nine responses (Table 7). Of the types of pleuritis, the necrotic or gangrenous type fits as a TC criterion, and is also recommended by Codex Alimentarius (1993). Moreover, according to Codex Alimentarius, suppurative pleuritis should lead to TC. However, this begs the question of whether suppurative pleuritis should always lead to TC? Or should the size of the lesion, the lesion stage (acute/chronic) and/or the existence of systemic affection be taken into consideration? Codex Alimentarius recommended, in a non-comprehensive way, that only pig carcasses with diffuse fibrinous or serofibrinous pleuritis are sent for TC, not considering other types of pleuritis.

However, after careful reflection, we agree with the opinion of Jensen et al. (2017), who stated that, if the lesion, even if acute, covers less than e.g., 25% of the pleura, and there are no complications, partial condemnation may be possible. Complications referred by Jensen et al. (2017) are synonymous with the signs of systemic change also described by Collins and Huey (2015), who stated that carcasses must be condemned if there is any sign of infection in the viscera, especially the liver, kidney or carcass lymph nodes.

Complications associated with pleuritis are very diverse, and those provided by our respondents can be seen in Table 7.

Since pleuritis is a very common post-mortem finding in finishing pigs (Alban et al., 2022; Vom Brocke et al., 2019), special attention should be given to the revision of the criteria for TC cases and more research should be developed to make any rational conclusion. Although it makes sense to operate with a fixed criterium regarding the degree of the lungs affected, such a limit should preferably be evidence-based, which the 25% limit referred to above is not.

**Table 7**
Other PMI findings indicating a generalised disease related to pleuritis provided by 15 respondents.

| PMI findings indicating generalised disease related to pleuritis | Number of answers |
|---|---|
| Acute pleuritis with or without extension | 4 |
| Acute state with more than 25% affected | 1 |
| Acute status | 1 |
| Extensive acute | 1 |
| Acute with purulent and/or fibrinous exudate | 1 |
| Type of pleural lesion | 9 |
| Abscesses | 1 |
| Chronic purulent pleuropneumonia | 1 |
| Fibrinous and serofibrinous | 2 |
| Suppurative lesions | 3 |
| Necrotic or gangrenous | 2 |
| Extension of lesions | 2 |
| More than 25% affected and have complications | 1 |
| Diffuse | 1 |
| Associated to other lesions or conditions | 4 |
| Other inflammatory lesions with reactive lymph nodes | 1 |
| Metastatic pneumonia | 1 |
| Generalised abscessation | 1 |
| Polyserositis | 1 |
| Wasting carcasses | 2 |
| Septic pleuritis | 2 |
| Total | 23[a] |

[a] Each respondent was able to provide more than one PMI finding indicator separately or together, so the total number of indicators is higher than the number of respondents.

*3.2.10. Pneumonia*

Pneumonia is an inflammation of the lungs that can be caused by numerous types of organisms (bacteria, viruses, parasites, fungi) or physical (foreign bodies) or chemical (toxins) agents. Classification of pneumonia is complex as it can be based on various criteria: aetiology, epidemiology, type of exudate (fibrinous, purulent), stage of disease (acute, subacute, or chronic) or main location of lesions (bronchopneumonia, interstitial pneumonia, lobar pneumonia, and focal pneumonia) (Collins and Huey, 2015; Jensen et al., 2017; Wilson, 2005).

From the 38 respondents' answers related to pneumonia as condemnation criterion, none chose the TC criterion "in all cases" (Table 2). This result is in accordance with the results reported by Alban et al. (2022), showing that pneumonia is not a common cause of TC. Although pneumonia is one of the main lesions observed in pig lungs during PMI in an abattoir (Collins and Huey, 2015; Vom Brocke et al., 2019), nearly all cases result in partial condemnation (Alban et al., 2022).

From the 23 respondents who chose the use of other PMI findings indicating generalised disease related to pneumonia, 15 provided more details (Table 8). Eight answers were included in the group of "type of pneumonia lesions", like abscesses (2), purulent exudate (3), and necrotic pneumonia (3). Based on Jensen et al. (2017), carcasses with those lesions (even if acute), so long as the lesions comprise less than 25% of the lung surface, may be declared fit for human consumption, while carcasses with lesions covering more than 25% of the lung tissue, or which have associated complications, require TC. An exception is focal pneumonia with disseminated (embolic) distribution (not reported by the respondents) that, in acute cases, always requires TC. Some answers given were partially in line with this judgement criterion proposed by Jensen et al. (2017), e.g.: acute stage with more than 25% affected; acute pneumonia with reactive lymph nodes and/or spleen (complications); more than 25% affected and have complications; extensive and severe bronchopneumonia (Table 8).

As was seen for pleuritis (Section 3.2.8), complications of pneumonia referred to by Jensen et al. (2017) are synonymous with signs of systemic change described by Codex Alimentarius (1993), Collins and Huey (2015), and Wilson (2005), and are a criterion for TC. Complications associated with pneumonia can be very diverse, as shown in Table 8: febrile carcasses; abscesses; endocarditis; reactive lymph nodes; arthritis; lymphadenitis; abscesses and arthritis; generalised

**Table 8**
Other PMI findings indicating a generalised disease related to pneumonia provided by 15 respondents.

| PMI findings indicating generalised disease related to pneumonia | Number of answers |
|---|---|
| Type of pneumonia lesion | 8 |
| Abscesses | 2 |
| Purulent exudate | 3 |
| Necrotic | 3 |
| Associated to other lesions or conditions | 7 |
| Febrile carcass | 2 |
| Abscesses, endocarditis, reactive lymph nodes | 1 |
| Arthritis | 1 |
| Lymphadenitis, abscesses and arthritis | 1 |
| Generalised abscessation, tail lesions | 1 |
| Abscesses in other locations | 1 |
| Acute | 4 |
| Acute state with more than 25% affected | 1 |
| Acute state | 2 |
| Acute with reactive lymph nodes and/or spleen | 1 |
| Extension of lesion | 3 |
| More than 25% affected and have complications | 1 |
| Extensive and severe bronchopneumonia | 2 |
| Total | 22[a] |

[a] Each respondent was able to provide more than one PMI finding indicator separately or together, so the total number of indicators is higher than the number of respondents.

abscessation; tail lesions; abscesses in other locations.

All this variability of indicators shown in the respondents' answers highlights the difficulty in harmonising these judgement criteria. However, we emphasise that the basic principles for correct judgement of pneumonia can be seen in detail in Jensen et al. (2017) and should include: stage of evolution (acute/chronic), extent of affected lung tissue, existence of systemic complications, and origin (aerogenous/haematogenous).

Codex Alimentarius (1993) recommended TC for any kind of acute pneumonia (such as widespread, severe, purulent bronchopneumonia, gangrene of the lungs, or necrotic pneumonia). This recommendation combines the three concepts of the type, extent, and severity of pneumonia into one: "acute pneumonia". For this reason, the authors of the current study suggests that should be provided am more objective and scientific-based recommendation that could be used at European level. Again, the limit for the percentage of the lungs affected before TC should be recommended should be based upon evidence.

## 4. Conclusions

To our knowledge, this is the first attempt to characterise, at European level, differences in the TC criteria used for a relevant set of post-mortem findings in slaughter pigs.

Diverse practical instructions regarding judgement of TC are operative in different European countries. The various TC criteria partly reflect that different combinations of lesions can be observed during PMI in finishing pigs. This constitutes a challenge regarding future harmonisation of the judgement criteria. To overcome this, we suggest a start is made by identifying the findings that reflect a generalised condition of disease, as this may often warrant TC. In line with this, it is important to look at whether the findings observed reflect an acute disease stage or not, because findings indicating prior lesions and, therefore, a non-acute condition can indicate a different impact on, e.g., food safety compared to an acute condition. Flexibility in how to declare meat unfit for human consumption should always exist, as the meat inspectors' judgement depends on the individual case, but it should not depend solely on the individual assessor. Still, the basic principles for judgement of post-mortem findings should be harmonised, preferably in an evidence-based way, focusing among other things, on the food safety impact related to the various findings. In this way, unnecessary condemnation can be avoided in a safe manner.

Further studies should be carried out to clarify and define the basis for the evidence-based TC of pig carcasses affected by PMI findings detected at slaughter.

## Funding source

This publication is based on work from COST Action 18105 (Risk-based Meat Inspection and Integrated Meat Safety Assurance; http://www.ribmins.com) supported by COST (European Cooperation in Science and Technology; http://www.cost.eu).

## Declaration of Competing Interest

None.

## Acknowledgements

We gratefully acknowledge the national contact points of RIBMINS for distributing the questionnaire and all respondents for participating in this study.

The participation of Madalena Vieira-Pinto was supported by the projects UIDB/CVT/00772/2020 and LA/P/0059/2020 funded by the Portuguese Foundation for Science and Technology (FCT).

## References

Alban, L., Petersen, J.V., Bækbo, A.K., Pedersen, T.Ø., Kruse, A.B., Pacheco, G., Larsen, M.H., 2021. Modernising meat inspection of pigs – A review of the Danish process from 2006-2020. Food Control 119 (107450), 1–11.

Alban, L., Vieira-Pinto, M., Meemken, D., Maurer, P., Ghidini, S., Santos, S., Gómez Laguna, J., Laukkanen-Ninios, R., Alvseike, O., Langkabel, N., 2022. Differences in code terminology and frequency of findings in meat inspection of finishing pigs in seven European countries. Food Control 132 (108394), 1–13.

Álvarez, R., Meléndez-Martínez, A.J., Vicario, I.M., Alcalde, M.J., 2015. Carotenoid and Vitamin A contents in biological fluids and tissues of animals as an effect of the diet: A review. Food Rev. Int. 31, 319–340. https://doi.org/10.1080/87559129.2015.1015139.

Arzoomand, N., Vågsholm, I., Niskanen, R., Johansson, A., Comin, A., 2019. Flexible distribution of tasks in meat inspection – A pilot study. Food Control 102, 166–172.

Bækbo, A.K., Petersen, J.V., Larsen, M.H., Alban, L., 2016. The food safety value of deboning finishing pig carcasses with lesions indicative of prior septicaemia. Food Control 69, 177–184.

Canadian Food Inspection Agency, 2021. 050R Red Meat Condemnation Report by Species for Federally Inspected Plants. Available online: https://www.agr.gc.ca/eng/canadas-agriculture-sectors/animal-industry/condemnations/ (accessed 5 June 2021).

Cardoso-Toset, F., Gómez-Laguna, J., Amarilla, S.P., Vela, A.I., Carrasco, L., Fernández-Garayzábal, J.F., Astorga, R.J., Luque, I., 2015a. Multi-etiological nature of tuberculosis-like lesions in condemned pigs at the slaughterhouse. PLoS One 10 (e0139130). https://doi.org/10.1371/journal.pone.0139130.

Cardoso-Toset, F., Luque, I., Amarilla, S.P., Gómez-Gascón, L., Fernández, L., Huerta, B., Carrasco, L., Ruiz, P., Gómez-Laguna, J., 2015b. Evaluation of rapid methods for diagnosis of tuberculosis in slaughtered free-range pigs. Vet. J. 204, 232–234. https://doi.org/10.1016/j.tvjl.2015.01.022.

Cardoso-Toset, F., Luque, I., Carrasco, L., Jurado-Martos, F., Risalde, M.A., Venteo, A., Infantes-Lorenzo, J.A., Bezos, J., Rueda, P., Tapia, I., Gortázar, C., Domínguez, L., Domínguez, M., Gomez-Laguna, J., 2017. Evaluation of five serologic assays for bovine tuberculosis surveillance in domestic free-range pigs from southern Spain. Prev. Vet. Med. 137, 101–104. https://doi.org/10.1016/j.prevetmed.2016.12.016.

Codex Alimentarius, 1993. Recommended International Code for Ante-Mortem and Post-Mortem Inspection of Slaughter Animals and for Ante-Mortem and Post-Mortem Judgement of Slaughter Animals and Meat. CAC/RCP 41-1993, pp. 1-69. Available online: http://siweb1.dss.go.th/standard/Fulltext/codex/CXP_041E.pdf (accessed 1 March 2022).

Collins, D.S., Huey, R., 2015. Meat inspection protocols. In: Collins, D.S., Robert, J., Huey, R.J. (Eds.), Gracey's Meat Hygiene, 11th ed. Wiley Blackwell, Hoboken, NJ, USA, pp. 185–222.

Commission Implementing Regulation (EU) 2019/627 of 15 March 2019 Laying down Uniform Practical Arrangements for the Performance of Official Controls on Products of Animal Origin Intended for Human Consumption in Accordance with Regulation (EU) 2017/625 of the European Parliament and of the Council and Amending Commission Regulation (EC) No 2074/2005 As Regards Official Controls. pp. 1–64. Available online: https://eur-lex.europa.eu/eli/reg_impl/2019/627/oj (accessed on 17 October 2020).

Correia-Gomes, C., Smith, R.P., Eze, J.I., Henry, M.K., Gunn, G.J., Williamson, S., Tongue, S.C., 2016. Pig abattoir inspection data: can it be used for surveillance purposes? PLoS One 11 (e0161990).

Edwards, D.S., Johnston, A.M., Mead, G.C., 1997. Meat inspection: an overview of present practices and future trends. Vet. J. 154, 135–147.

Guardone, L., Vitali, A., Fratini, F., Pardini, S., Goga, B.T.C., Nucera, D., Armani, A., 2020. A retrospective study after 10 years (2010–2019) of meat inspection activity in a domestic swine abattoir in Tuscany: the slaughterhouse as an epidemiological observatory. Animals 10 (1907), 1–17.

Harley, S., More, S., Boyle, L., O' Connell, N., Alison Hanlon, A., 2012. Good animal welfare makes economic sense: potential of pig abattoir meat inspection as a welfare surveillance tool. Ir. Vet. J. 65 (11), 1–12.

Herenda, D., Chambers, P.G., Ettriqui, A., Seneviratna, P., da Silva, D.J.P., 1994. Chapter 2. General pathological conditions. In: Manual on Meat Inspection for Developing Countries. FAO animal production and health paper; Food and Agriculture Organization of the United Nations, ISBN 92-5-103304-8. Available online: https://www.fao.org/3/t0756e/t0756e00.htm (accessed 1 March 2022).

Jensen, H.E., Leifsson, P.S., Nielsen, O.L., Agerholm, J.S., Iburg, T., 2017. Meat Inspection – The Pathoanatomic Basis, First ed. Biofolia, Denmark.

Kruse, A.B., Larsen, M.H., Skou, P.B., Alban, L., 2015. Assessment of human health risk associated with pyaemia in Danish finisher pigs when conducting visual-only inspection of the lungs. Int. J. Food Microbiol. 196, 32–39.

Lindén, J., Pohjola, L., Rossow, L., Tognetti, D., 2014. Meat inspection lesions. In: Ninios, T., Lindén, J., Korkeala, H., Fredriksson-Ahomaa, M. (Eds.), Meat inspection and control in the slaughterhouse, 1st ed. Wiley Blackwell, West Sussex, UK, pp. 163–199.

Lopez, A., 2001. Respiratory system, thoracic cavity and pleura. In: McGavin, M.D., Carlton, W.W., Zachary, J.F. (Eds.), Thomson's Special Veterinary Pathology, Third edition. Mosby, St. Louis, USA, pp. 178–182.

Ninios, T., 2014. Judgment of meat. In: Ninios, T., Lindén, J., Korkeala, H., Fredriksson-Ahomaa, M. (Eds.), Meat Inspection and Control in the Slaughterhouse, 1st ed. Wiley Blackwell, West Sussex, UK, pp. 219–224.

OIE (World Organisation for Animal Health), 2021. Terrestrial Animal Health Code, Chapter 6.3 Control of Biological Hazards of Animal Health and Public Health Importance Through Ante- and Post-Mortem Meat Inspection. Available online: https://www.oie.int/en/what-we-do/standards/codes-and-manuals/terrestrial-code-on

line-access/?id=169&L=1&htmfile=chapitre_control_bio_hazard.htm (accessed 1 March 2022).
Opriessnig, T., Coutinho, T.A., 2019. Erysipelas. In: Zimmerman, J.F., Karriker, L.A., Ramírez, A., Schwartz, K.J., Stevenson, G.W., Zhang, J. (Eds.), Diseases of Swine, 11th edition. John Wiley & Sons Ltd, Ames, IA, pp. 835–843.
Pedersen, T.Ø., Bækbo, A.K., Petersen, J.V., Larsen, M.H., Alban, L., 2017. Evaluation of the food safety risk associated with de-boning of Danish sows with chronic purulent lesions indicative of prior septicaemia. Fleischwirtsschaft Int. 2, 66–70.
Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). Available online: https://eur-lex.europa.eu/eli/reg/2016/679/oj (accessed 1 March 2022).
Robbe-Austerman, S., Thoen, C.O., 2019. Tuberculosis. In: Zimmerman, J.F., Karriker, L. A., Ramírez, A., Schwartz, K.J., Stevenson, G.W., Zhang, J. (Eds.), Diseases of Swine, 11th edition. John Wiley & Sons Ltd, Ames, IA, pp. 971–980.
Scollo, A., Gottardo, F., Contiero, B., Mazzoni, C., Leneveu, P., Edwards, S.A., 2017. Benchmarking of pluck lesions at slaughter as a health monitoring tool for pigs slaughtered at 170 kg (heavy pigs). Prev. Vet. Med. 144, 20–28.
Stärk, K.D.C., Alonso, S., Dadios, N., Dupuy, C., Ellerbroek, L., Georgiev, M., Hardstaff, J., Huneau-Salaün, A., Laugier, A., Mateus, A., Nigsch, A., Afonso, A., Lindberg, A., 2014. Strengths and weaknesses of meat inspection as a contribution to animal health and welfare surveillance. Food Control 39, 154–162.
Thompson, K., 2006. Bones and joints. In: Grant Maxie, M. (Ed.), Jubb, Kennedy and Palmer's Pathology of Domestic Animals, 5th edition. Saunders, London, UK, pp. 2–180.
Vieira-Pinto, M., Esteves, A., Saraiva, C., Fontes, C., Martins, C., 2013. Inspeção sanitária *post mortem* do pulmão e coração de suínos. Principais alterações observadas. In: Joaquim, M., Vieira-Pinto, M. (Eds.), Inspeção Sanitária de Suínos. Sociedade Científica de Suinicultura, pp. 75–90.
Vieira-Pinto, M., Azevedo, J., Poeta, P., Pires, I., Ellerbroek, L., Lopes, R., Veloso, M., Alban, L., 2020. Classification of vertebral osteomyelitis and associated judgment applied during post-mortem inspection of swine carcasses in Portugal. Foods 9 (1502).
Vom Brocke, A.L., Karnholz, C., Madey-Rindermann, D., Gauly, M., Leeb, C., Winckler, C., Schrader, L., Dippel, S., 2019. Tail lesions in fattening pigs: relationships with post mortem meat inspection and influence of a tail biting management tool. Animal 13 (4), 835–844. https://doi.org/10.1017/S1751731118002070.
Wang, Q., Chang, B.J., Riley, T.V., 2010. Erysipelothrix rhusiopathiae. Vet. Microbiol. 140, 405–417.
Weisbrode, S.E., 2007. Bone and joints. In: McGavin, M.D., Zachary, J.F. (Eds.), Pathological Basis of Veterinary Disease, 4th edition. Mosby Elsevier, St. Louise, MO, pp. 1041–1105.
Wilson, W.G., 2005. Wilson's Practical Meat Inspection, 7th ed. Blackwell Publishing Ltd., UK.