

Modernization of swine slaughter inspection in swine slaughter establishments - risk-based inspection

Scientific opinion



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Foreword

We are delighted to present this document, the fruit of the labors of a multidisciplinary and multi-institutional team. In mid-2014 a project was designed in order to modernize the sanitary inspection for swine slaughter, and commissioned from Brazilian Agricultural Research Corporation (Embrapa) in March 2015. Five years of intense work followed. More is still required so that the goals of the Department of Inspection of Animal Products (Dipoa) can be attained.

It has been an unparalleled experience both to coordinate a wide array of activities and to assimilate the methodologies underpinning the decision-making process for risk managers. The results presented herein will bring gains for public health, and provide security to the inspection service, and share responsibilities with the industry.

Jalusa Deon Kich

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Introduction

The main goal of the veterinary inspection of animal products is to safeguard consumers' health and ensure the production of healthy foods. It also shares with other sectors the responsibility for meeting animal welfare and sanitary programs in force in Brazil. There has been a long-standing separation of the evaluation of animals, carcasses and offals into ante-mortem and post-mortem inspection. However, with increased regulatory demands, the inspection activity began to absorb tasks such as facility-based, document-based and process-based verifications varying in accordance with the needs of the slaughtering and processing establishments.

The identification of meat not fit for human consumption has historically been made during post-mortem inspection of carcasses and viscera by means of examinations involving visualization, palpation and incision in order to detect abnormalities in the tissues. These techniques were based on Robert von Ostertag's "*Handbuch der Fleischbeschau*", published for the first time in 1892 and translated into English by Wilcox in 1904. Ostertag's system became the world standard and was also adopted as the model for the Brazilian legislation (Von Ostertag, 1904). For over one century this inspection system has been efficient in protecting consumers against the classic hazards such as the *Mycobacterium* genus of bacteria and zoonotic parasitoses (Ghidini et al., 2018). Brazil's - and the world's - swine-raising industry has undergone a process of intensification and improvement of output, based upon animals being kept in confinement, and the adoption of technology and scientific advancements in the sanitary control of herds. Changes in animal-raising practices have profoundly transformed the risk profile of pork as a vehicle of zoonoses. In the past, parasitic diseases and tuberculosis were the most important diseases, among pathologies that produced macroscopic lesions. Today, these zoonoses are very well controlled in the animal production phase, with very little evidence of lesions. Most of the microorganisms related to the macroscopic lesions commonly observed at post-mortem inspection do not pose a risk to human health; by and large, they cause disease only in the animals (EFSA, 2011).

The World Health Organization, in order to provide countries with a basis for preparing public policies and defining evidence-based priorities estimated the global burden of foodborne illnesses (FBI) and listed 31 hazards. Approximately 550-600 million cases of diseases were attributed to infectious agents that cause diarrhea, accounting for 230-420,000 deaths (WHO, 2015). Reports on foodborne diseases by the European Union (European Food Safety Authority - EFSA), United States (Centers for Disease Control and Prevention - CDC) and Brazil (Sistema de Informação de Agravos de Notificação - SINAN/SVS) have consistently reported such bacteria as *Escherichia coli*, *Salmonella*, *Campylobacter* and certain viruses as the most frequent causes of foodborne diseases. Specifically discussing swine-raising, Baer et al. (2013) highlighted six pathogens of concern in food safety: *Salmonella*, *Campylobacter*, *Trichinella*, *Toxoplasma*, *Listeria* and methicillin-resistant *Staphylococcus aureus*. The most frequently found pork-related foodborne etiology in the United States between 2012 and 2015 was *Salmonella*, accounting for 46% of outbreaks (Self et al., 2017). Detecting all these pathogens at slaughter, or in the pork itself, depends on laboratory testing.

Therefore, the current list of consumer health hazards is made up of microorganisms that do not produce observable lesions on the inspection lines. This change in the scenario has led to a need for the revision and modernization of the meat inspection system in pork-producing countries, so that the focus passes to risks that effectively pose a threat to food safety. The need for a change has been advocated by acknowledged meat hygiene authorities worldwide: Blackmore (1983); Hathaway et al. (1987); Berends et al. (1993); Johnston (1994), and many others. However, it is essential that any changes in existing systems be based on sound scientific principles of meat hygiene and risk analysis; they must not be unduly influenced by outside issues (Huey et al., 2014).

Therefore, countries with significant swine-raising industries, such as some member states of the European Union and the United States, have invited international evaluation of their changes in the examinations on the inspection lines, basing them on risk and including sanitary control concepts as applied to the production chain (EFSA, 2011; FSIS, 2018). The main reasons given for the change has to do with the fact that the traditional ante-mortem and post-mortem methods do not in themselves detect sub-clinical or asympto-

matic zoonoses, and that they enable cross contamination on the slaughter line (EFSA, 2011). In Brazil, the Regulation on the Industrial and Sanitary Inspection of Animal Products (Riispoa), first enacted in 1952 and remaining in force for 65 years, determined the disposition of carcasses and offals in accordance with the lesions that were found. The current Riispoa, published in 2017, maintains the determination of disposition in accordance with lesions; however, it promotes changes in procedures, provided that they are based on risk assessment. Specifications as to official interventions in swine slaughter are laid down in ordinance 711/1995 (Brazil, 1995) which establishes anti-mortem and post-mortem inspection by the Federal Inspection Service (SIF). The SIF is made up of veterinarians (Federal Agricultural Inspectors/Auditors), and federal agricultural inspection technicians and auxiliaries, who visualize, palpate and dress all slaughtered animals. This system has generated a large set of procedures which have been reviewed in order scientifically to investigate their present-day relevance to the prevention of pork-consumption-related hazards.

The risk-management agency - the Ministry of Agriculture, Livestock and Food Supply's Department of Inspection of Animal Products (Dipoa) - in the current proposal-forming review, requested that Embrapa Swine & Poultry produce a risk assessment consisting of a qualified and referenced scientific opinion on the matter (Official Letter no. 48/DIPOA/SDA). To comply with the request, the present project entitled "Revision and Modernization of Ante-Mortem and Post-Mortem Inspection Procedures Applied in Swine-Slaughtering Establishments Inspected by the Federal Inspection Service" has been prepared by a team comprising Embrapa Swine & Poultry personnel, as well as university specialists recommended by Brazilian Agricultural Research Corporation (Embrapa). The scope of the project encompasses establishments registered in the Federal Inspection Service, which account for approximately 86% of swine slaughter in Brazil (IBGE, 2018). The animals slaughtered in these establishments come from industrialized production systems (that are confinement-based and highly technologically-intensive) supervised by veterinary control. In every case the lot to be slaughtered travels with a "Sanitary Bulletin" issued by the veterinarian, containing information on mortality, diseases detected in the lot, and the use of antimicrobials. The results found in this setting do not apply to other production and inspection systems or to wild suidae and backyard farming herds.

The strategy adopted in the project was organized into inter-related action plans to cover the following steps:

- 1) Quantification of lesions found by SIGSIF (Federal Inspection Service Management Information System) and classification in accordance with the public health risk.
- 2) Identification and prioritization of public health hazards ascribed to pork meat coming from industrialized swine-raising, by a process of risk-assessment and risk-prioritization.
- 3) Production of supplementary national and regional data to underpin the decision. Thus, the following aspects were studied: the occurrence of zoonotic microorganisms on carcass surfaces and tissues, (the *Salmonella*, *Yersinia*, *Listeria*, *Mycobacterium*, *Toxoplasma*, and *Trichinella* genera; and the Hepatitis E virus); the etiology of lesions compatible with zoonotic parasitoses, and the viability of pathogens in chronic pleural adhesion lesions. The sensitivity of macroscopic examinations was evaluated.
- 4) Review of the existing legislation on the two steps of inspection (ante-mortem and post-mortem); with an assessment of the relevance and suitability of the procedures laid down in order to control the hazards defined in previous steps, and the putting forward of alternative procedures.
- 5) Validation of the changes to procedures in six slaughterhouses located in the states of Minas Gerais (MG), Paraná (PR), Rio Grande do Sul (RS) and Santa Catarina (SC).
- 6) Training of trainers and validation of recommendations.
- 7) Evaluation of the economic impact of the proposed changes.
- 8) The General Coordinator for Special Programs of Dipoa drafted a proposal for microbiological criteria intended to reduce pathogens, to be established in the program, and applied in swine slaughter.
- 9) Drafting of a proposed change in inspection procedures to be applied in swine slaughterhouses.

Briefly, the project had seven action plans, which jointly: characterized the situation in Brazil concerning detections in the present meat inspection system; prioritized the hazards ascribed to the consumption of pork and set out which pathogens are the most essential to control; reviewed the relevant legislation; analyzed current ante-mortem and post-mortem inspection procedures; produced data to support decisions; and compared and validated the changes in procedures as carried out in six plants located in four states of Brazil, varying among themselves by the extent of technology applied to the slaughter. In addition to a series of scientific technical publications it underpinned the actions resulting from the Normative Instruction that defined the microbiological criteria of the self-control and official control of swine carcasses, which was published in the Official Gazette of the Federal Government (DOU), Normative Instruction (IN) N° 60, dated December 20, 2018. Likewise, the lifting of the restriction on the export of carcasses that have been submitted to the Final Inspection Department was based on a Technical Note that rested upon the results of the project, as defined in Ordinance 1,304, published in the Official Gazette of the Federal Government (DOU) on 07/10/2018. And as the final result of the proposal, the risk-based inspection system for pork was regulated on December 14, 2018, by Normative Instruction N° 79.

Detections in the current ante-mortem and post-mortem inspection system for swine: evaluation of the SIGSIF 2012-2014 data

The first step of the project was made up of the analysis of the SIGSIF system (Federal Inspection Service Management Information System) in order to perform a nationwide diagnosis of detections made in swine slaughterhouses by the Federal Inspection Service (SIF). To this end, the data for 2012, 2013 and 2014 as recorded by the SIF in 114 establishments throughout Brazil were analyzed. The data were obtained from two Excel files: one contained information on monthly slaughter by species and category of animal; the other contained the causes for condemnation on the inspection line, and the numbers thereof.

Initially, an exploratory analysis of the data was performed in order to evaluate the consistency of the data and ensure that the results would be robust. In the second phase the data were analyzed for the numbers and frequencies of deviations and/or partial or total condemnations of carcasses, heads or viscera and the numbers and percentage frequencies of causes of the recorded deviations/condemnations. The results are presented below in a descriptive form, on tables and in charts in order to facilitate visualization of the information of interest. The computer program SAS (Version 9.4) was used to carry out the analysis.

During the period being analyzed, the slaughter data of 94,262,328 pigs, in 114 establishments, were assessed. The regional distribution of slaughter was as follows: South 64,920,532 (68.9%); South-east 14,724,409 (15.6%); Center-west 14,581,229 (15.5%) and North-east 36,158 (0.04%). During that period, 9,611,170 deviations/carcass condemnations were recorded, accounting for 10.2% of slaughtered swine.

The most-frequently occurring deviations / condemnations of offals were in lungs (31.53%), followed by livers (15.24%), kidneys (14.44%) and hearts (8.49%). The carcasses of 10.2% of the pigs suffered some kind of depreciation, going to partial use, partial condemnation or total condemnation. Causes of deviations/condemnation with a percentage frequency greater than or equal to 0.1%, compared with the overall total number of pigs slaughtered, are listed in Table 1. Causes of deviations/condemnation with a frequency below this cutoff point are clustered and included in the same table under "Other causes".

Table 1. Causes of deviations/partial or total condemnation of viscera, heads and carcasses of 94,262,328 pigs slaughtered in 114 establishments in which the Federal Inspection Service is present, from 2012 to 2014.

Cause of deviation/ condemnation	Establishments where occurred (%)	Number of condemnations
Spleens		
Contamination	84 (73.68)	2,296,301 (2.4361)
Congestion	72 (63.16)	501,379 (0.5319)
Splenitis	51 (44.74)	418,271 (0.4437)
Other causes*	46 (40.35)	382,702 (0.4060)
Heads		
Contamination	105 (92.11)	1,989,108 (2.1102)
Other causes*	75 (65.79)	379,025 (0.4021)
Hearts		
Pericarditis	103 (90.35)	5,421,244 (5.7512)
Contamination	110 (96.49)	2,165,419 (2.2972)
Adherences	23 (20.18)	135,113 (0.1433)
Other causes*	68 (59.65)	281,951 (0.2991)
Stomachs		
Contamination	51 (44.74)	823,382 (0.8735)
Other causes*	42 (36.84)	222,228 (0.2358)
Livers		
Perihepatitis	102 (89.47)	4,223,650 (4.4807)
Larval migration	99 (86.84)	3,687,256 (3.9117)
Contamination	111 (97.37)	2,512,045 (2.6650)
Congestion	106 (92.98)	2,484,803 (2.6361)
Steatosis	76 (66.67)	811,152 (0.8605)
Other causes*	108 (94.74)	647,265 (0.6867)
Intestines		
Contamination	104 (91.23)	3,738,422 (3.9660)
Enteritis	72 (63.16)	1,108,530 (1.1760)
Lymphadenitis	36 (31.58)	184,655 (0.1959)
Pneumatosis	77 (67.54)	138,514 (0.1469)
Other causes*	98 (85.96)	487,848 (0.5175)

Cause of deviation/ condemnation	Establishments where occurred (%)	Number of condemnations
Tongues		
Contamination	106 (92.98)	2,485,851 (2.6372)
Other causes*	60 (52.63)	252,639 (0.2680)
Lungs		
Enzootic pneumonia	86 (75.44)	6,161,113 (6.5361)
Emphysema	84 (73.68)	5,251,820 (5.5715)
Asphyxia	3 (2.63)	3,890,402 (4.1272)
Aspiration of blood	91 (79.82)	3,250,675 (3.4485)
Congestion	101 (88.60)	3,007,462 (3.1905)
Contamination	108 (94.74)	2,305,373 (2.4457)
Aspiration of water	81 (71.05)	2,305,292 (2.4456)
Pulmonary atelectasis	73 (64.04)	958,011 (1.0163)
Pulmonary congestion	61 (53.51)	780,719 (0.8282)
Pneumonia	68 (59.65)	723,826 (0.7679)
Adherences	33 (28.95)	432,559 (0.4589)
Pleuritis	28 (24.56)	183,220 (0.1944)
Other causes*	99 (86.84)	473,017 (0.5018)
Kidneys		
Urinary cyst	96 (84.21)	4,495,756 (4.7694)
Nephritis	107 (93.86)	4,213,585 (4.4701)
Contamination	104 (91.23)	2,291,914 (2.4314)
Congestion	103 (90.35)	1,076,121 (1.1416)
Uronephrosis	35 (30.70)	711,807 (0.7551)
Anemic infarct	86 (75.44)	570,495 (0.6052)
Other causes*	65 (57.02)	248,481 (0.2636)
Carcasses		
Adherences	86 (75.44)	3,507,003 (3.7205)
Contamination	99 (86.84)	1,693,656 (1.7967)
Bruising	93 (81.58)	1,215,404 (1.2894)
Pleuritis	59 (51.75)	799,588 (0.8483)
Abscess	96 (84.21)	546,738 (0.5800)
Traumatic lesion	38 (33.33)	261,163 (0.2771)

Cause of deviation/condemnation	Establishments where occurred (%)	Number of condemnations
Lymphadenitis	67 (58.77)	232,706 (0.2469)
Pneumonia	75 (65.79)	185,480 (0.1968)
Cryptorchidism	66 (57.89)	140,848 (0.1494)
Mange	41 (35.96)	128,416 (0.1362)
Suppurated lesion	25 (21.93)	121,694 (0.1291)
Excess scalding	70 (61.40)	110,245 (0.1170)
Peritonitis	73 (64.03)	95,351 (0.1012)
Other causes*	103 (90.35)	572,878 (0.6077)

*Other causes = the sum of all causes of deviations/condemnation that individually presented a frequency below 0.1% of the total number of swine slaughtered between 2012 and 2014.

It can be observed that the contamination of abdominal viscera is among the main causes of deviations/condemnation, the most frequent causes being intestines (3.97% of the total number of swine slaughtered), spleens (2.44%) and stomachs (0.87%). For other abdominal viscera, contamination was among the three main causes of deviations/condemnation, affecting 2.67% of livers and 2.43% of kidneys that were inspected. The relative frequency of deviation/condemnation in relation to the total number of swine slaughtered was also high in thoracic viscera, coming to 2.45% of lungs and 2.30% of hearts. Contamination was the second most frequent cause (1.80%) of deviations/condemnation in carcasses, only behind adherences, the most frequent cause (3.72%).

Lesions indicative of a diagnosis of zoonoses, even at a percentage rate below 0.1%, were evaluated separately. In Table 2, the frequencies of condemnations are presented, and the SIF numbers of the establishments, by state, in which the condemnations occurred.

Table 2. Distribution of zoonosis-related condemnations, recorded in SIGSIF from 2012 to 2014, by State in which the 114 SIF-inspected swine-slaughter establishments are located, compared against 94,262,328 slaughtered swine.

Condemnation	States (total no. SIF-inspected swine slaughter establishments)													Total (114)
	BA (2)	DF (1)	GO (1)	MG (28)	MS (2)	MT (5)	PR (18)	RS (20)	SC (19)	SE (1)	SP (17)			
Lymphadenitis														
SIFs w/ condemnation	0	0	1	12	2	4	11	17	17	0	11	0	11	75
Condemnations	0	0	6,041	147,661	718	196	19,546	385,058	166,345	0	35,078	0	35,078	760,643
Erysipelas														
SIFs w/ condemnation	0	1	1	3	0	1	9	10	9	0	4	0	4	38
Condemnations	0	13	7	693	0	1	95	2,571	218	0	671	0	671	4,269
Endocarditis														
SIFs w/ condemnation	0	0	0	5	2	0	5	3	5	0	3	0	3	23
Condemnations	0	0	0	55	5	0	167	997	578	0	13	0	13	1,815
Cysticercosis														
SIFs w/ condemnation	1	0	1	12	0	0	0	2	1	1	7	1	7	25
Condemnations	9	0	3	735	0	0	0	7	42	2	71	2	71	869
Sarcosporidiosis														
SIFs w/ condemnation	0	0	1	2	0	0	2	1	10	0	1	0	1	17
Condemnations	0	0	2	3	0	0	121	1	354	0	1	0	1	482
Tuberculosis														
SIFs w/ condemnation	0	0	0	2	0	0	3	4	0	1	2	0	2	12
Condemnations	0	0	0	11	0	0	5	14	0	6	7	0	7	43

BA-Bahia; DF-Distrito Federal; GO-Goiás; MG-Minas Gerais; MS-Mato Grosso do Sul; PR-Paraná; RS-Rio Grande do Sul; SC-Santa Catarina; SE-Sergipe; SP-São Paulo.

Lymphadenitis was the zoonosis-related lesion most frequently recorded in SIGSIF: it occurred in 75 SIFs (65.78%). In the three years of the study, 760,643 / 94,262,328 (0.8%) deviations/condemnations were caused by it, accounting for 8,069 deviations/condemnations per million swine slaughtered. The major target of deviations/condemnation due to lymphadenitis was carcasses, with 273,686 records for the period (2,903 swine/million slaughtered), followed by the intestines with 184,708 records (1,960 swine/million slaughtered). Granulomatous lymphadenitis is caused by mycobacteria, *Mycobacterium avium* complex (MAC), which have been overwhelmingly identified in intensive swine-raising, although there is the occasional occurrence of *M. Tuberculosis* complex (MCTb). As shown on Table 2, tuberculosis is the least-frequently reported zoonosis found in SIF-inspected swine slaughterhouses. Only 22 carcass condemnations were recorded in the three years under study, which represents 0.22 swine/million slaughtered. Records of tuberculosis in SIGSIF, albeit scarce, were confirmed by the state-level Office of Superintendents for Agriculture, of Mapa.

Suspected erysipelas lesion was the second most-common finding within the zoonoses group. Of the total of 4,269 records of deviations/condemnation due to erysipelas, 808 were in carcasses; accounting for 8.6 carcasses railed out/condemned for every one million swine slaughtered. This lesion occurred most frequently in Rio Grande do Sul and the profile of occurrence was restricted, because 1,960 records out of a total of 2,571 came from only two SIF-inspected units (SIF 102 and SIF 2146). Erysipelas is of concern for the health of farm workers and workers in the meat-producing plants, because transmission is by the contact of skin compromised by abrasions or lesions, with infected animals and their tissues (Markey et al., 2013).

Endocarditis led to 1,815 deviations/condemnations being recorded (19.3/ million slaughtered) among 23 SIFs, the majority of which concentrated in the Southern Region. The highest frequency of condemnation was for carcasses (837 records - 8.9 swine/million slaughtered), followed by hearts (234 records - 2.5 swine/million slaughtered). In the case of carcasses recorded as condemned, there may well have been, apart from the heart lesion, the involvement of other organs or carcass parts that led to the total condemnation. Endocarditis is most frequently caused by bacteria of the *Streptococcus* genus, particularly *Streptococcus suis* and erysipelas-causing *Erysipelothrix*

rhusiophatiae (Jensen et al., 2010). In this case, the importance of the zoonosis is predominantly linked to occupational transmission, either by contact with contaminated tissues or by aspiration of the agent.

There were fewer records of the frequency of foodborne parasitic zoonoses than other causes. For cysticercosis, it was possible to ascertain that there were 869 records in Brazil among 25 SIFs (21.92% of the total), accounting for 9.2 cases for each million swine slaughtered. However, 647 of the condemnations took place in one single SIF (SIF 2484) in the state of Minas Gerais, and the record was confirmed by the Office of the State Superintendent for Agriculture of Mapa. The majority of the lesions were in the heart (668 records - 7.1 swine/million slaughtered), followed by carcasses (79 records - 0.84 swine/million slaughtered). Sarcosporidiosis was rarely reported, 482 occurrences in three years, which means 5.1 per million swine slaughtered. It is interesting to observe that of the 17 SIF - inspected establishments that recorded the condemnations/deviations, 10 are located in Santa Catarina (354 records), and one SIF alone (SIF 4569) reported 207 cases. Nearly all the records relate to the condemnation of the carcass (476 records - 5.1 swine/million slaughtered).

Figure 1 shows the major causes of carcass deviations/condemnations recorded in SIGSIF. It can be seen that most are related to: raising-phase diseases such as adherences, pneumonias and abscesses; events leading up to slaughter, such as traumatic lesions; and failures in the slaughter process, such as the leakage of intestinal contents.

In the past, as reported by Ribeiro (1951), the major causes of swine carcass condemnations were lesions compatible with tuberculosis and cysticercosis, which are easily detectable on the inspection line. The declining importance of these lesions, documented in the present study, is a consequence of the improvements over many years in the methods used in Brazilian hog-raising. Evolving sanitary and biosafety controls, good production practices, and the increasing use of technology-intensive and confinement conditions for hog-raising have reduced the incidence of classic zoonoses such as tuberculosis and cysticercosis. However, the intensive raising system has also led to the spread of foodborne etiological agents that can cause disease in consumers,

Modernization of swine slaughter inspection in swine slaughter establishments - risk-based inspection 25

which are frequently present in the digestive systems of hogs at slaughter. Failures in the slaughter process that allow the leakage of intestinal contents can lead to the contamination of carcasses and viscera by these pathogens. This scenario clearly indicates the need to adapt inspection procedures to enable the detection of these risks and mitigation of them. The complete report on this action plan was published by Coldebella et al. (2018).

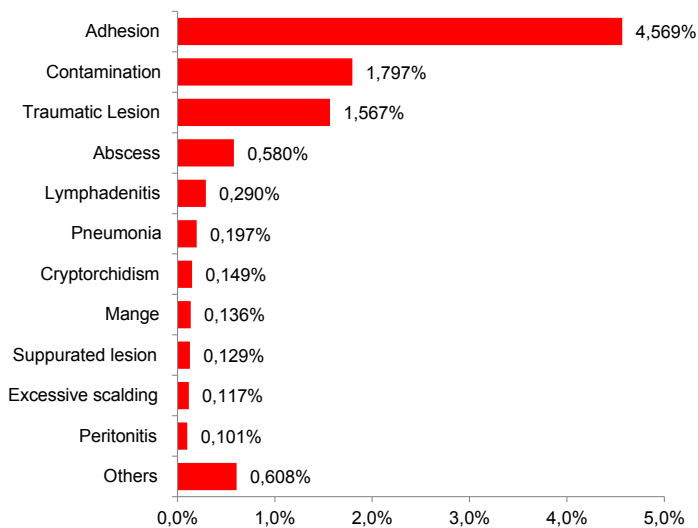


Figura 1. Causes of carcass condemnations/deviations in swine slaughtered in Brazil from 2012 to 2014 (94,262,328 swine slaughtered in 114 establishments).

Qualitative evaluation of risks in order to prioritize biological public health hazards in the industrial pork-production chain

Microbiological risk analysis (MRA) which aims to protect consumers' health, is indicated by the World Health Organization (WHO) as the most appropriate method for ensuring the production of safe products (FAO/WHO, 1999). It is a tool enabling the available information to be organized in such a form as to be translated into risk, helping create decision-making rules. In regard to food safety, MRA consists of a systematic analytical approach that aims to support the understanding of, and management of, microbiological risk issues (Hoornstra; Notermans, 2001). In Brazil, the use of risk-based tools for public health management is still scarce (Santos et al., 2014), since, to date, only two food-related risk-assessment studies have been published (Mürmann et al., 2011; Oliveira, 2013). Nonetheless the adoption of risk-based decision tools will inevitably increase, and qualitative or quantitative models are increasingly likely to be created in the field of public and animal health.

Concerning food inspection, a risk-based approach was used in order to propose adjustments to swine-carcass inspection procedures in the European Union (EFSA, 2011). The process culminated in a 2014 regulation (Commission Regulation no. 219/2014) which altered post-mortem inspection rules in swine. The inspection system is entitled Visual-only Meat Inspection. Then, in 2018, the United States (FSIS, 2018) announced a proposal that changes inspection procedures in swine slaughter establishments. The US approach is based on the concepts of Hazard Analysis and Critical Control Points (HACCP). The system was announced as the New Swine Inspection System (NSIS).

In the present study, the goal of this step was to perform a quantitative risk analysis in order to prioritize the biological hazards linked to the consumption of pork and pork products in Brazil, providing information upon which to base changes in the inspection routine for pork products.

The assessment answered the following question: **“what is the risk to human health of a given biological hazard when carried by pork and pork-products obtained from Brazil’s intensive hog-raising system?”** Animal health or occupational health-related hazards were not evaluated. The analysis limited itself to hog-raising systems deemed to be industrialized, herein defined as herds for which there was control of origin, of feed, and for which access to farms and veterinary-technical assistance were made available. These herds are often part of vertically-integrated systems; however, cooperative and independent systems may also be industrial owing to their features of technology-intensiveness and sanitary controls.

The risk-assessment used in the study was adapted from the model proposed for *Codex Alimentarius* (FAO, 1999), and comprises the following steps:

- 1) Hazard identification;
- 2) Hazard characterization;
- 3) Evaluation of exposure;
- 4) Risk characterization.

The model comprises the interaction of a series of dimensions that describe the process from the presence of hazards in the animals up until the consumption of a contaminated product. A qualitative scale (from 1 to 5) was attributed to each dimension: its interactions are measured by a qualitative matrix in accordance with Costa et al. (2017).

After the model was applied, the hazards were prioritized in accordance with the risk posed to human health by the consumption of pork and pork products.

Hazard identification

For the present risk assessment, a hazard is defined as an “agent or metabolic product of a biological agent capable of causing an adverse effect for a human being through the consumption of pork and pork products”.

A systematic search of the literature was carried out in order to identify the hazards (Grant; Booth, 1999) using these key words: **(bacterial agents OR viral agents OR fungal agents OR parasitic agents) AND (swine OR pork OR pig)**, covering the population of interest and the topic studied. The search was carried out in January 2015, in English and Portuguese, using the PubMed, ScienceDirect, ISI and Web of Science platforms, and summaries of such specialized events as SafePork and IPVS; searches in Portuguese were also carried out including unindexed databases. Hazards contained in Brazilian regulations and in official reports of the Ministry of Agriculture, Livestock, and Food Supply (MAPA) were also included.

For a hazard to be deemed relevant and be included in the evaluation, a positive response to the following question was necessary:

- 1) Can the hazard lead to an infection or poisoning or infestation in humans after the consumption of pork?

Can the hazard lead to an infection or poisoning or infestation in humans after the consumption of pork?

- 2) Is the hazard present in the population of hogs for industrial production in Brazil?
- 3) Can the hazard be introduced during slaughter and processing?

Evidence was considered from textbooks, scientific articles and reports produced by official agencies in order to answer each question. The answer to the third question, specifically, considers the possible introduction of a hazard either as waterborne, or through contact with handlers' skin, secretions or mucosae.

Evaluation of consumer exposure

The initial presence, which is the starting-point of the model, took into consideration the presence of a hazard in the individual (hog) and in the herd:

- 1) The hazard is rare both in individual hog and in the lot, and is detected sporadically or in exceptional circumstances.
- 2) The hazard present in several animals of each herd (widely spread in the herd), but in few lots.
- 3) The hazard is present in only a few animals in few herds, but will be found at both levels.
- 4) The agent is present in few animals but in several lots.
- 5) The hazard is present in several lots and in several animals in the lot.

Evaluation of the degree of exposure of the consumer took into consideration the occurrence at stages between primary production (e.g. hogs housed on the farm) and consumption. Each step was assessed for the amplification or reduction effect on the initial presence of each hazard. After this, the likelihood of any individual being exposed to a given hazard owing to consumption of pork or pork products was described as follows:

- 1) Consumption exceptionally leads to exposure.
- 2) Consumption leads to exposure on few occasions.
- 3) Exposure might possibly occur as a result of consumption.
- 4) Exposure will occur for the case of most consumption events.
- 5) Exposure is highly likely as a result of consumption.

Probability of amplification

Amplification is deemed to be the likelihood of increasing the initial presence of a given agent, and is the result of interaction between places on the carcass where the hazard is more usually expected to be present (location), and the agent's multiplication characteristics on meat and meat products (metabolism).

The location on the carcass is thus related to the likelihood of spread of the hazard from the initial location of contamination: the scale used ranges from 1 (lower) to 5 (higher probability) in accordance with the following definition:

- 1) The hazard is present in the form of cysts in the musculature or organs.
- 2) The hazard is more usually present in lymphoid organs that are handled during the slaughter or in inedible sites, although it may exceptionally be found in edible sites.
- 3) Present in specific organs used to prepare certain pork by-products.
- 4) The hazard is more usually present in mucosae or lesions.
- 5) The hazard is more usually present in intestinal contents.

However, metabolism has to do with the likelihood of the hazard's multiplication in meat or by-product and the scale used is from 1 (lower) to 5 (greater likelihood) in accordance with:

- 1) The multiplication or metabolism of the hazard occurs only in the animal (e.g. there is no multiplication in the meat or by-products).
- 2) The hazard depends on specific factors for multiplication (atmosphere, pH).
- 3) The hazard needs a specific temperature condition for its multiplication.
- 4) The population of the hazard grows rapidly in the meat and by-products at room temperature (25°C or higher).
- 5) The population of the hazard grows in meat and by-products at a refrigerated temperature.

Probability of reduction

This is the likelihood of being able to reduce the hazard on the carcass/product by detecting it through visual inspection, which will enable part of - or all of - the affected area to be removed, and the reduction of the characteristics of resistance to physical agents (heat and cold) for the hazards that have been modeled; the five levels of reduction go from the highest likelihood to the lowest likelihood:

- 1) Lesions are visible upon inspection of the carcass or of the organs, and may be removed from the carcass.
- 2) Highly sensitive to both physical agents (freezing and the heat of domestic cooking).
- 3) The hazard can withstand a temperature of 60°C for longer than 10 minutes, but without a thermal resistance structure such as endospores.
- 4) Hazards possessing thermal resistance structures such as endospores.
- 5) The hazard is deemed heat-stable.

Hazard characterization

Characterization of the hazards has revealed information on the most relevant features of each hazard for performing an assessment of them; above all characteristics relating to pathogenicity and the magnitude of the adverse effects linked to each one of the hazards.

Pathogenicity

Pathogenicity has been defined to be the capacity of an agent (for example a hazard) to cause the disease, lesion or specific symptom; and, in this context, it has been used to offset the lack of information on dose response associated with the hazards that were evaluated. Qualitatively, it is described as a:

- 1) Hazard of very low pathogenicity, only in exceptional situations does it cause a food poisoning event.
- 2) Hazard of low pathogenicity for healthy humans via the food route, but it is acknowledged to be pathogenic to specific groups within the population.
- 3) Moderately pathogenic hazard: most exposed individuals will present a picture of food poisoning after the ingestion of medium-sized or high doses of the hazard.
- 4) Highly pathogenic hazard via the food route and most individuals exposed to low doses of the hazard will present food poisoning.
- 5) Highly pathogenic hazard via the food route and in theory contact with the agent will be sufficient to cause food poisoning.

Adverse effects

Adverse effects have to do with individual clinical manifestations when infection occurs, and the impacts of this for society, and are used as an assessment of the consequences, and are qualitatively defined as:

- 1) Negligible individual consequences without repercussions for society at large.
- 2) Low-impact individual consequences, temporary limitation of activity, without repercussions for society.
- 3) Medium-impact individual consequences, with temporary limitation of activity, and social costs due to hospitalization; low levels of lethality.
- 4) High-impact individual consequences, long-term incapacitation, with a possibility of cure with or without sequelae, hospitalization costs, lethality ranging from low to medium.
- 5) Severe individual consequences (high lethality), low probability of cure.

Risk characterization

The characterization of the risks then resulted from the interaction between the dimensions of exposure and adverse effects, with regard to the **probability of the occurrence of food poisoning after the consumption of pork and pork products associated with the adverse effects of this event**, qualitatively described in five levels:

- 1) The risk for humans is very low.
- 2) The risk for humans is low.
- 3) The risk for humans is moderate.
- 4) The risk for humans is high.
- 5) The risk for humans is very high.

Interactions between the dimensions of the model

Interactions between the several dimensions that are taken into consideration in risk characterization and occur according to a qualitative matrix of five levels of likelihood (Chart 1), where [i] is the line index and [j] is the column index.

Chart 1. Qualitative matrix used for the interaction among the several dimensions of the model for risk characterization.

	2 nd Dimension [j]				
1 st Dimension [i]	1	2	3	4	5
1	1	1	1	1	1
2	2	2	2	2	3
3	2	2	3	4	4
4	3	3	4	4	5
5	3	4	4	5	5

The resulting matrix was therefore made up of five levels organized in accordance with the systematics proposed by Elmontsri (2014). Since the matrix is not symmetrical there is a need to specify which dimensions have been modeled in lines [i] or columns [j] (Table 3).

Table 3. Specification of interactions among the dimensions that were used in the evaluation of risks in accordance with their modeling indices and the respective resulting dimension.

Resulting dimension	Interaction
5. Preliminary activities	Likelihood of occurrence (<i>i</i>) * Adverse effect (<i>j</i>)
4. Probability of occurrence	Final presence (<i>i</i>) * pathogenicity (<i>j</i>)
3. Final presence	Amplified presence (<i>i</i>) * Likelihood of reduction (<i>j</i>)
2. Amplified presence	Initial presence (<i>i</i>) * Likelihood of amplification (<i>j</i>)
1. Probability of amplification	Location on the carcass (<i>i</i>) * metabolism of agent (<i>j</i>)

Numbers between parentheses are the results of interactions in the sequence in which they were modeled.

Three scenarios were modeled: raw products, cooked products, and fermented/cured products. The sensitivity and uncertainties of the parameters that were used in the model were analyzed. This document presents the results for the raw product scenario.

Detailed information on the remaining scenarios and assessments is available at:



Sensitivity analysis

Sensitivity analysis assessed the impact of a change to the values of the scales of the dimensions of the model upon the final estimated risk. To achieve this, the dimensions “initial presence”, “likelihood of amplification” and “likelihood of reduction” were changed within the domain (e.g. 1-5) and any difference in the resulting risk was observed for each scenario that was modeled.

Hazards identified after systematic analysis of the literature

One hundred and twenty-four (124) hazards were identified, and of these, 88 were excluded because they were not deemed to be agents that are transmitted by the food route when consuming pork.

Of the 36 remaining hazards, 14 were excluded because they have not been present among market hogs for 20 years, while one was included as possibly being introduced during the industrial processing, which brings the total of hazards that are relevant in the risk assessment of the raw product to 23. Sixteen of the hazards are bacterial (*Clostridium botulinum*, *Yersinia pseudotuberculosis*, *Escherichia coli* (O157H7), *Brucella suis*, *Mycobacterium tuberculosis*/*M. bovis*, *Erysipelothrix rhusiopathiae*, *Clostridium perfringens*, *Aeromonas* sp., *Arcobacter* sp., *Listeria monocytogenes*, *Yersinia enterocolitica*, *Mycobacterium avium*, *Staphylococcus* sp., *Campylobacter coli*, *Escherichia* sp., *Salmonella* sp. [non-typhoidal]); five (5) are parasitic (*Giardia* sp., *Cysticercosis/taeniasis*, *Sarcosporidiosis*, *Balantidium coli*, *Toxoplasma gondii*) and two (2) are viruses (Rotavirus, Hepatitis E).

Risk characterization (estimated final risk)

The final risk was modeled for the 23 hazards deemed relevant in the preceding step and proposed for the raw product: none was classified as being very high risk. Among the identified hazards, only *Salmonella* sp. presented a high risk. Ten bacterial hazards and *Toxoplasma gondii* were ranked as low risk, while 11 microbiological and parasitic hazards were ranked very low risk (Figure 2).

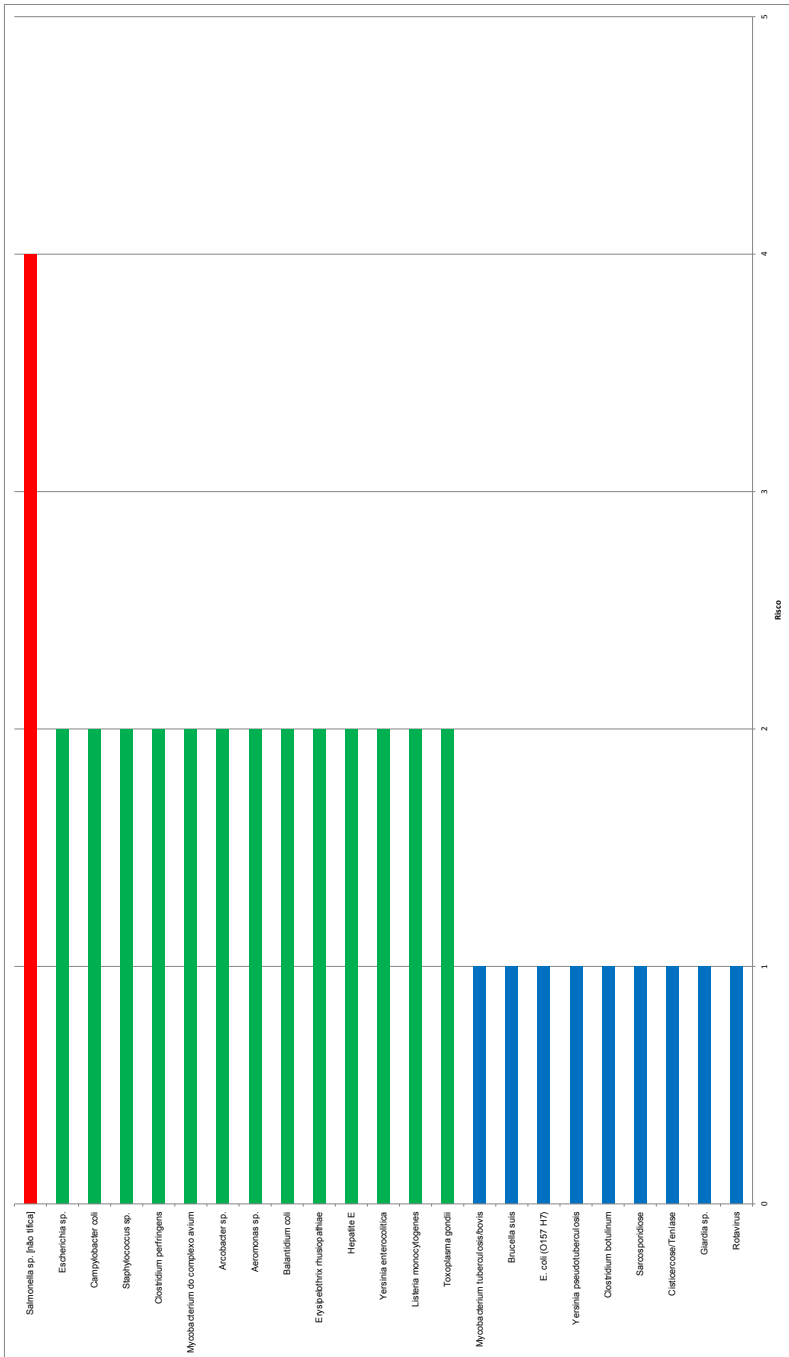


Figure 2. Risk characterization for the 23 hazards under study in relation to the consumption of raw pork.

Specific failures in biosafety will lead to the spread of complex-cycle bacterial hazards such as *Salmonella* sp. (Kich et al., 2005). These bacterial hazards often do not cause lesions or clinical science, and may go unperceived in herds. Raised levels of initial presence, allied to the likelihood of amplification, and the multiplication of the hazard on the carcass and in products, were determining factors for these results. By and large, the raised initial presence of a bacterial hazard will be amplified by events that enable it to multiply, whereas heat destruction of microorganisms depends on the duration of exposure of the hazard to a given temperature. For this reason, the application of a given time-temperature binomial in the processing plant or in a consumer's home may not be sufficient to obtain total destruction of the hazard present in high quantities in the product, and thus increase the exposure of the consumers.

Parasitic hazards were characterized as falling between very low and low risk in the scenarios that were assessed. This is the consequence of a low initial presence of parasites in herds, the result of an increased control of the means of production (e.g. inputs, technical assistance and handling techniques), which minimize the life cycle of certain parasites, as well as the low probability of amplification owing to the parasites being unable to multiply in the foodstuff. Sensitivity analysis of the "initial presence" dimension (e.g. serious failure in biosafety with an increased initial presence of hazards among herds) led to an increase in the exposure to all hazards, which when added to the associated consequences, changed the result to high risk. This scenario is compatible with a non-technology-intensive production setting, which underscores the fact that the results observed in the present study have to do with a highly technology-intensive production chain.

Toxoplasma gondii and *Balantidium coli* were the two parasitic hazards possessing the highest levels of risk, although both were characterized as being low-risk in all the scenarios that were modeled. This is due to the fact that they are more frequently present in Brazilian herds than the other parasites (Brito et al., 2012; Santos et al., 2017). Despite being more commonly present in market hog herds, the fact that they have a low probability of amplification (in other words, they have no capacity for multiplying on carcasses or in by-products) and a high probability of reduction (Belluco, et al., 2016; Acha; Szyfres, 2003) (in that they are sensitive to freezing and/or heat), keeps them at a low level of risk. When the initial presence is changed to very high, only

Toxoplasma gondii changed its level of risk to high, while *Balantidium coli* remained low, mainly because of its low pathogenicity and the less severe consequences of infection (Acha; Szyfres, 2003). The increased final risk resulting from a change in the initial presence of *T. gondii* aligns with the concepts of control of parasitic hazards: these are based on the disruption of the parasite's cycle of transmission at the animal-raising step. However, if there is a failure in the disruption of the cycle, the technological freezing or heat-based process will be the only tools available, since *T. gondii* will not cause lesions that can be identified and removed from the infected swine carcass (Jones; Dubey, 2012).

The results of the qualitative risk models that are generated for raw pork products have shown that the hazards that are characterized with the highest levels of risk (e.g. bacterial hazards) do not appear clinically in the lots and are thus not directly detected by the inspection. Additionally, the intense manipulation of carcasses in search of lesions may itself lead to the spread of the bacterial hazards assessed as having the highest risk, as is the case for *Salmonella* sp. However, since 14 of the 23 hazards listed in the model are excreted in the feces, visible fecal contamination must be controlled, and indicators such as the count of enterobacteriaceae must be incorporated into the food businesses' self-controls. Simultaneously, the results of this model provide guidance for the change in the inspection procedures that are applied in Brazil to the slaughter of swine from industrial herds. The results show the need to understand the control of pathogens from an integrated perspective, encompassing all steps in production; and the importance of the use of risk assessment as an ancillary tool in the decision-making process of public health.

The complete report on this action plan is available at:



DOCUMENTOS 186

Recommendations for the application of risk-based inspection in swine slaughterhouses with on-site Brazilian Federal Inspection Service (SIF)

The risk assessment identified and characterized 23 biological hazards linked to the consumption of pork. These results were checked against detections on inspection lines recorded in SIGSIF, and supplemented by data produced by the project, in order to justify whether the inspection procedures should be maintained or altered. The discussion was guided by the hazards listed in the qualitative risk analysis and was addressed in three groupings. The first group has to do with the (essentially bacterial) hazards carried by feces/intestinal content; the second addresses parasitic disease-causing hazards; the third group addresses lesions that are frequently found on inspection lines and are caused by microorganisms that may or may not be present in the qualitative risk assessment. The hazards listed in the risk prioritization and that are not covered by these three groupings, are given in Table 9, in which the official Dipoa monitoring and control programs are shown. Those not monitored by Dipoa will be addressed individually under the item “other hazards”.

Further detailing on the tests to be performed and the distribution of competencies will be presented in the item on “Changes in procedures for the inspection and classification of pigs, carcasses and parts of carcasses”.

Fecal/intestinal content-borne hazards

Of the 23 hazards listed in the qualitative risk assessment, 14 are carried in the feces and may be present in the hog's intestinal contents during processing on the slaughter line (Table 4). This fact drew attention to the importance of contamination of carcasses and viscera by intestinal contents, and its significance for the risk of pork products.

Table 4. Qualitative assessment of the risk of biological hazards that may be present in the feces/intestinal contents of hogs, as regards the consumption of raw pork.

High risk	Low risk	Very low risk
<i>Salmonella</i> (non-typhoidal)	<i>E. coli</i>	<i>Yersinia pseudotuberculosis</i>
	<i>Campylobacter coli</i>	<i>Clostridium botulinum</i>
	<i>Arcobacter</i> sp.	<i>E. coli</i> (O157 H7)
	<i>Yersinia enterocolitica</i>	Rotavirus
	<i>Clostridium perfringens</i>	<i>Giardia</i> sp.
	<i>Aeromonas</i> sp.	
	Hepatitis E virus	
	<i>Balantidium coli</i>	

As shown by the qualitative risk assessment, the highest-risk hazard is *Salmonella* sp. The scientific literature overwhelmingly proves that *Salmonella* sp. is excreted in the hog's feces, and may be carried in the intestinal contents as well as other sites such as the lymph nodes, tonsils and oral cavity (Castagna et al., 2004; Vieira Pinto et al., 2005; Kich et al., 2011; Vieira Pinto et al., 2012; Guerra Filho et al., 2016). The importance of this fact for the surface contamination of carcasses is widely supported by scientific studies (Borch et al., 1996; Berends et al., 1997; Alban; Stärk, 2005; Baptista et al., 2010; Pesciaroli et al., 2017). The average results for the isolation of *Salmonella* sp. on carcasses in the pre-chill step range widely (5.4% to 24%) among studies carried out in Brazil; this is probably a result of the sampling plan and the influence of the number of infected swine in slaughtered lots, as well as of differences between slaughter processes (Kich et al., 2011; Silva et al., 2012). The data obtained by the exploratory program carried out by Dipoa in slaughterhouses throughout Brazil estimated that 10% (CI 7.50 - 13.22) of carcasses were positive before the chill step (Brasileiro et al., 2017). Furthermore, the present project carried out a supplementary investigation of *Salmonella*, *Yersinia* and *Listeria* on the surfaces of 378 carcasses at three establishments slaughtering hogs from three different animal origins systems (integration, cooperatives and the independent market). *Listeria* was not found, and only one carcass tested positive for *Yersinia enterocolitica*, showing that the latter is a biological hazard of low occurrence on carcasses, and it was additionally classified as being low risk in the qualitative risk analysis.

Salmonella sp. on the other hand, showed a positive-carcass prevalence of 15.87% at the pre-chill step (Meneguzzi et al., 2017). On the basis of these studies, a realistic estimate of the prevalence of *Salmonella* sp.-positive swine carcasses at the pre-chill stage in SIF-inspected establishments in Brazil appears to range from 10% to 15%.

SIGSIF data show that visible (non-specific) contamination is among the main causes of deviations/condemnation, attaining 1.8% for carcasses that were inspected and 2.11% for heads that were inspected. These frequencies were even higher in viscera: 3.97% for intestines; 2.67% for livers; 2.64% for tongues; 2.45% for lungs; 2.44% for spleens; 2.43% for kidneys and 2.30% for hearts (Coldebella et al., 2018). These detections on the inspection line reflect deficiencies in the slaughter process operations, above all those pertaining to the leakage of intestinal contents owing to failures of bunging and evisceration. Despite being important macroscopic observations, in themselves they are insufficient to predict whether microorganisms will be present on carcass surfaces. The visual inspection of the carcass only detects visible contamination, whereas, for the presence of a biological hazard on the carcass, non-visible contamination arising from process failures and cross-contamination during slaughter also make an important contribution. As regards cross-contamination and process failures, other forms of contamination - in addition to carcass contamination by leakage of the intestinal contents of the animal itself - are important: from other carcasses, equipment, instruments, handling, and environmental contamination.

Self-control measures to prevent contamination are already the object of official verification by visual examination of carcasses and viscera prior to a remediation process with the mechanical removal of the affected part. In this case, the legislation in force allows for official intervention in the slaughter process, by reducing the slaughter speed or capacity whenever there is a sign of sanitary compromise. In addition to maintaining the target of reducing the occurrence of fecal contamination, the adoption of control measures for contamination not detectable by visual examination is also suggested. It is known that operational hygiene programs, good manufacturing practices, and critical control point analyses aim to reduce these risks and are subject to official verification. However, the adoption of a hygiene indicator for monitoring the process will provide numerical data for monitoring and establishing targets

and criteria. Among indicator microorganisms, counts of enterobacteriaceae on carcass surfaces prior to the chill step have been proposed and adopted since they cover not only the aspects of direct fecal contamination of the carcass, but also indirect aspects such as those resulting from cross-contamination and hygiene program failures.

Investigations carried out on carcass surface samples, taken in accordance with Circular Letter 130/2007, involving 1,150 carcasses and 13 SIF-inspected slaughterhouses in the state of Santa Catarina, showed that the median enterobacteriaceae count did not exceed 1.52 log colony forming units per cm² (log UFC cm⁻²) (Corbellini et al., 2016). The present project sampled 378 carcasses and the enterobacteriaceae count for the majority of carcasses was below 2.3 log CFU.cm⁻² (Meneguzzi et al., 2017). The process hygiene criterion established by the European Union for swine carcasses, sampled at the pre-chill step, does not allow enterobacteriaceae to exceed 3 log UFC.cm⁻² on the scheduled sampling plan (Commission Regulation no. 2073/2005). Brazilian exploratory studies have thus shown that Brazil's slaughter system is prepared for a self-control program based on microbiological process-hygiene indicators as is the case for enterobacteriaceae.

Studies have shown that although the enterobacteriaceae count is an indicator of process hygiene and is strongly associated with the occurrence on carcasses of *Salmonella* sp., the influence of the daily variation in frequency of *Salmonella* in slaughter establishments prevents this indicator from being used as a predictor of contamination by that biological hazard (Corbellini et al., 2016). The result is associated with the fact that in addition to process hygiene, detecting *Salmonella* on carcasses is influenced by the number of lots having a high prevalence of hogs carrying *Salmonella* in their intestinal content that are slaughtered on a given day. Even when the process is suitably hygienic, there may be a failure to avoid *Salmonella* contamination of carcasses in lots for slaughter under a high contamination pressure owing to a large number of infected hogs. Therefore, a program in Brazil to reduce pathogens on swine carcasses must, in addition to the process hygiene indicator microorganism (Enterobacteriaceae), cover *Salmonella* specifically, since it is the highest-risk biological hazard. The working group that was set up, and which included members of the present project, and the advisory council for animal product microbiology that was appointed by Ordinance 17/2014 (SDA/

MAPA), drafted a technical note indicating the performance standards to be attained by establishments' self-control programs. The Technical Note was the basis for Normative Instruction nº 60, published in DOU on December 20, 2018, and which defined the microbiological criteria for self-control and official controls of swine carcasses.

In regard to other biological hazards listed by the quantitative risk analysis, and classified as posing low and very low risk (Table 4), it can be predicted that the measures to be taken by industrial producers in order to attain the limits set forth in the Normative Instruction for reductions in *Salmonella* sp. and enterobacteriaceae will be sufficient to control these other hazards on the carcass.

Under the regulations in force, in order to detect fecal contamination on the carcass, it is laid down that 100% of carcasses and viscera are to be monitored by visual examination and physical removal (trimming) when a deviation is identified: this is the competency of the official service. Given the frequency of fecal contamination observed in the SIGSIF data, it is clear that official inspection staff are under heavy demand to correct these deviations. Add to this the fact that correction by physical removal of the visibly affected part does not in itself prevent a recurrence of contamination. Therefore, preventive measures against contamination by intestinal contents must be the major duty of the sanitary management of the slaughter establishment. This process will be amenable to verification by the official service, and be subject to product-related and process-related enforcement actions when necessary. It should be stressed that efficient control of direct and indirect contamination by intestinal contents mitigates several hazards, regardless of their risk characterization (high, low or very low). Procedures regarding the official verification of process hygiene, in turn, will be presented in proposals for procedures for each inspection line, in the item entitled "Changes in procedures for the inspection and classification of pigs, carcasses and parts of carcasses".

SIGSIF data show a higher frequency of deviation/condemnation owing to visible contamination on heads (2.11%) than on carcasses (1.8%). Apart from this aspect, the splitting of the carcass while keeping the head on it is one of the slaughter line operations that brings a high risk of contamination of the meat (Zdolec et al., 2015). The oral cavity is a location known to be contaminated and the tonsils may be colonized by a wide variety of food pathogens such as *Salmonella* and *Yersinia*. The lymph nodes of the jowl region drain the oral cavity and are often contaminated by *Salmonella*, mycobacteria and *Yersinia* (Castagna et al., 2004; Zdolec et al., 2015). This being the case, as a support measure for the reduction of macroscopically visible and non-visible contamination, there is an indication for the complete removal of the head, and the elimination of incisions of lymph nodes of this region. This measure aims to avoid exposure of the oral cavity and tonsils in the slaughter environment, reducing the risk of environmental contamination (surfaces, instruments and air), which can be the source of pathogenic bacteria for carcasses during the processing. To mitigate these risks, it is sufficient to manipulate the head and tongue in a dedicated location, trimming and removing lymph nodes in their entirety, and disposing of the meat and other edible by-products to processing, and these are recommendations of the project in order to prevent risks to consumer health. We recommend validating, in Dipoa, some treatment for when raw material such as jowl is used in sausage products.

Parasitic disease-related hazards

This group of hazards covers sarcosporidiosis and cysticercosis - which are classic parasitoses detected on inspection lines, and are caused by very low-risk biological hazards (*Sarcocystis* and *Cysticercus*); *Toxoplasma gondii* is not detected on inspection lines and is characterized as low-risk; and *Trichinella spiralis*, which despite being characterized as negligible risk, has been included owing to the fact that it remains a requirement for Brazil to export pork.

Sarcosporidiosis and Cysticercosis (*Sarcocystis* and *Cysticercus*)

In the retrospective assessment of detections in SIGSIF, 9.2 occurrences/million swine slaughtered were reported owing to cysticercosis, and 5.1 occurrences/million swine slaughtered owing to sarcosporidiosis: both are considered to be of extremely low occurrence. There has been a reduction in condemnations for cysticercosis from 8% of carcasses in the 1940s (Ribeiro, 1951) to 0.0001% today (Coldebella et al., 2018). This reduction in findings and in condemnations over time reflects advances in the production system both technologically speaking and in terms of sanitary control in the hog-raising phase. Confinement systems and biosafety disrupt the life cycle of these parasites, resulting in increasingly low levels of detection. In the period under study, condemnation for sarcosporidiosis was 0.0005% of carcasses.

A national prospective laboratory-testing study of suspected zoonotic parasitosis lesions that were detected by SIFs was carried out from May 2017 to May 2018 in order to supplement the data available within the scope of this project, in accordance with Memorandum no. 125/2017/CRIS-DIPOA/CGPE- DIPOA/ MAPA. Samples underwent histopathological testing at Embrapa Swine & Poultry; over the period there were 296 suspected cases of sarcosporidiosis, 64 of hydatidosis and one suspected case of cysticercosis (Table 5).

The only sample suspected for cysticercosis was inconclusive because it was impossible to identify the larval phase of the parasite, which confirms the diagnosis. Samples of muscles from 296 animals (294 being breeders) were tested in order to confirm suspected sarcosporidiosis (tongue, heart and diaphragm). Of these 296 samples tested, granulomas compatible with sarcosporidiosis were observed in 137. Sarcocysts (a form of the parasite in the muscle of the intermediate host) were observed in 47, whether accompanied by granulomas or otherwise. The remaining 131 did not present any lesion compatible with sarcosporidiosis.

Table 5. Results of the prospective study of suspected zoonotic parasitosis lesions as detected by the Federal Inspection Service, and histopathological confirmation (May 2017 to May 2018).

Suspicion by SIF	Material colhido	SIF	Origem	Categoria animal	Número de amostras	Diagnóstico histopatológico (número de amostras)
Sarcosporidiosis	Muscle	4569	RS, SC, PR, MS, GO, MG	Breeder	294	Lesion compatible with Sarcosporidiosis (n=163; 48 confirmed with parasite present in musculature; 131 remaining without compatible lesion)
	Tongues	3094	PR	Breeder	1	Sarcosporidiosis (n=1)
	Hearts	996	NI	NI	1	Sarcosporidiosis (n=1)
		377	NI	NI	3	Inconclusive (n=2) Compatible with <i>Cysticercus tenuicollis</i> (n=1)
Hydatidosis		772	NI	NI	1	Inconclusive (n=1)
	Livers	1156	NI	Finisher	37	<i>Cysticercus tenuicollis</i> (n=4) Compatible with <i>Cysticercus tenuicollis</i> (n=9) Inconclusive (n=22) Non-parasitic lesions (n=2)
		784	NI	Finisher	23	Inconclusive (n=3) Compatible with <i>Cysticercus tenuicollis</i> (n=3) <i>Cysticercus tenuicollis</i> (n=17)
Cysticercosis	Livers	784	NI	NI	1	Inconclusive (n=1)

NI=not identified; GO= Goiás; MG= Minas Gerais; MS= Mato Grosso do Sul; PR= Paraná; RS= Rio Grande do Sul; SC= Santa Catarina; TO= Tocantins.

Suspected cases of hydatidosis were attributed to the detection of a cyst in the liver; however, no parasites suggestive of *Echinococcus granulosus* were found. Inconclusive results are those in which there were neither parasites nor characteristic structures inside the cyst (Table 5). Compatible lesions alone were found in 13 cases; however, *Cysticercus tenuicollis* was diagnosed in 21 cases (Table 5), the larval phase of *Taenia hydatigena*, a parasite whose definitive hosts are canids and ruminants, swine being intermediate hosts (Dermauw et al., 2016). *Taenia hydatigena* is not described as one of the teniases/cysticercoses that affect humans, in the **Documents of the OIE**. Despite not being zoonotic in nature, it clearly demonstrates biosafety failures in the hog-raising phase that enable the parasite to perpetuate its development cycle. It is understandable that it might be recorded as hydatidosis, since distinguishing between *Taenia hydatigena* cysts and those of *Echinococcus granulosus* is difficult on the inspection line, and may lead to classification errors (Nguen et al., 2016).

The results that were found enable the conclusion that the detection of suspected cysticercosis and sarcosporidiosis lesions in finisher pigs was very scarce (Table 5). There is therefore no justification for the incision of muscles and viscera to detect zoonotic parasitoses. However, given the conclusive findings of sarcosporidiosis in breeding sows, it is understood that the form of inspection laid down for enabling detection in this animal category should be maintained.

Toxoplasma gondii

Toxoplasma gondii has been characterized as low-risk when associated with the consumption of fresh pork (Figure 3). Serological studies conducted in Brazil point to endemic infection on hog farms. Garcia et al. (1999) found a 24% seropositivity in the north of Paraná; 9.6% was reported in São Paulo by Suarez-Aranda (2000); and approximately 50% in Minas Gerais by Santos et al. (2017). The data vary a great deal as a function of the local biosafety conditions, and should therefore not be extrapolated.

Since the evaluation procedures performed on the inspection lines are incapable of identifying *Toxoplasma gondii*, we performed a serological study and the detection of the parasite by Polymerase Chain Reaction in the diaphragm muscle of slaughtered swine. We sampled 135 hogs from 27 farms in the mid-west region of Santa Catarina and north-west of Rio Grande do Sul that adhere to the integrated production system. The tests to detect the agent in the muscle all returned negative. Five animals, from five different farms, tested positive on serological testing. Although the study did not demonstrate that the pathogen occurs in the muscle, the positive serology indicates that there is contact with *Toxoplasma gondii* in the hog-raising phase. Because it is impossible to detect contaminated meat in the sanitary inspection routine at slaughter, and owing to the fact that the multiplication and dissemination phases of the parasite occur only on the farm, good agricultural practices and good biosecurity practices should be adopted by farms, above all to prevent the presence of felids on farms, or bar their access to them. Good agricultural practices, aiming to prevent swine coming into contact with *Toxoplasma gondii*, are described in the literature and should be executed. Even so, the understanding of the sources of infection in humans must be boosted so that the official service can rank its priorities, as well as the most appropriate links in the production chain where control and monitoring, if needed, can be applied.

Trichinella spiralis

The risk of *Trichinella spiralis* was deemed negligible in lots of market hogs because the result both of the qualitative risk-analysis and of the laboratory tests performed by the SIF indicated an absence of the hazard in lots of hogs purchased from sanitarily controlled premises. In compliance with the post-mortem procedures provided for in the former regulation (article 214 of Decree no. 30,691, enacted March 29, 1952) laboratory tests were performed on approximately 58 million carcasses from 2010 to 2015: in every case they tested negative. As part of the experiments performed in the present study, 135 supplementary molecular (enzyme digestion) tests were performed, all also returning negative. Additionally, a World Health Organization document (WHO, 2015) estimated 4 deaths from among 4,474 cases of human trichinellosis, while for non-typhoidal salmonellosis there were 59,153 deaths from among 78,707,591 cases. In light of the aforementioned information, it is be-

lieved to be possible to eliminate from the official line the performance of tests that sample material (a fragment of diaphragm) for the presence of *Trichinella spiralis* in lots coming from commercial hog-raising activities.

Matters of compliance with the supplementary requirements for export may be addressed as part of the self-controls intended to prove the requirements, in accordance with the bilateral agreements signed by Mapa, and also in accordance with the assessments of the equivalence attained by Brazil's risk-based inspection system.

Positive serology has been detected in the monitoring of feral swine in certain regions of Brazil: therefore, these suidae have been excluded from the 'negligible' hazard classification. They are beyond the scope of the present project, **available on the OIE site.**

Lesions produced by microorganisms - listed or otherwise - in the qualitative risk-assessment, and that are frequently detectable on inspection lines

Granulomatous lymphadenitis

The hazards listed in the risk assessment that cause granulomatous lymphadenitis were *Mycobacterium* of the *avium complex* (low risk) and *Mycobacterium bovis/tuberculosis* (very low risk). The currently expected and performed examinations that aim to provide visual detection of granulomatous lymphadenitis include official assessment of 100% of viscera, with incision of easily-accessed lymph nodes. The more thorough evaluation of lymph nodes on the carcasses and the reassessment of viscera takes place in the Final Veterinary Inspection Department (DIF). The disposition of the carcasses is provided after evaluation of the set of carcass-plus-viscera and is based on the findings on the inspection lines. Table 6 shows the occurrence of lymphadenitis found on the several inspection lines and the repercussions of these findings from the lines on the condemnation/disposition of the carcasses. The inspection line that examines the mesenteric lymph nodes was where the findings were most frequently detected. Of the total number of carcasses railed out to the

Final Inspection Department (DIF), 0.2904% were as a result of granulomatous lymphadenitis.

In 2017, in order to provide up-to-date data on the etiology of the granulomatous lymphadenitis detected in swine in Brazil, establishment SIF 637 sampled lymph nodes with characteristic lesions coming from 19 different slaughterhouses in the states of MG, SP, PR, SC and RS. Samples underwent: histopathological testing for mycobacteria, Ziehl-Neelsen testing to identify acid-alcohol resistant bacilli (AARB), and isolation of mycobacteria followed by PCR identification of species. Granulomatous histopathological lesions were observed in 85.1% of sampled tissues, showing a good correlation with the macroscopic examination on the slaughter line. Given one sample per lot (origin) in the sampled swine, lymph nodes from 399 lots underwent isolation for *Mycobacterium* spp., of which 128 returned positive (32.08%). Of the 128 positive lots, 98 (76.56%) were identified as *Mycobacterium avium hominissuis* (MAH), 2 (1.56%) as *Mycobacterium bovis* (*M. bovis*) and 28 (21.87%) did not belong to the species that were tested, and were characterized only at genus level (*Mycobacterium* spp). Acid-alcohol resistant bacilli (AARB) were observed in 71.7% of MAH samples; AARB were observed in 75% of *Mycobacterium* spp. samples; and in one of three samples of *M. bovis*. MAH was the most-frequently diagnosed subspecies in granulomatous lymphadenitis of swine in Brazil; there were only two positive origins for *M. bovis* (Mori, 2019).

The handling and incision of lymph nodes and heads has been suggested to be the origin of cross-contamination of carcasses, owing to the presence of such pathogens as *Salmonella* (Vieira Pinto et al., 2012) and *Yersinia* (Zdolec et al., 2015) in these tissues. In the case of *Salmonella*, specifically, the effect of lymph node inspections on swine carcass contamination has been predicted by Costa et al. (2017), demonstrating that the handling and incising may be an important source of contamination. In a study by Biasino et. al. (2018), it was seen that there was an association between head-cutting procedures, with incisions into the palatine tonsils, and a high level of contamination by hygiene indicator bacteria and *Salmonella*. This cross-contamination might also theoretically occur for other hazards such as *Mycobacterium* sp.

Given the different frequencies of detection of granulomatous lymphadenitis on different inspection lines, and the effect of the examination on carcass cross-contamination, in accordance with the aforementioned studies, it is suggested that the examination only of the mesenteric lymph nodes be maintained on the intestine inspection line. The loss of sensitivity of the detection of granulomatous lymphadenitis owing to the reduction in examinations was estimated, to assist in taking this decision. Inspection data gathered in 2017 by 20 SIF-inspected establishments in five states of Brazil (SC, RS, PR, SP and MG) were used (Table 7) and the loss of sensitivity was calculated in accordance with the evaluations that were performed (Table 8).

Table 6. Occurrences of granulomatous lymphadenitis by lymph node in accordance with the inspection line and type of examination performed (Coldebela et. al. 2018).

Inspection line	Type of examination performed			Percentage of occurrences per number of slaughtered animals
	Visual	Palpation	Incision	
Head and jowl lymph nodes			x	0.0440
Stomachs			x	0.0389
Intestines	x		x	0.1959
Lungs		x	x	0.0373

Table 7. Results for detection of granulomatous lymphadenitis in 20 Federally-inspected establishments, in accordance with the chain of lymph nodes examined.

Occurrence of lymphadenitis	Category (number of animals examined)	
	Breeder (74,887)	Finisher (2,222,428)
Total for lymphadenitis (%)*	396 (0.53)	19,742 (0.89)
% Mesenteric	0.49	0.76
% Lymph nodes of head	0.04	0.18
% Mediastinal	0.03	0.04

*Including cases where more than one chain of lymph nodes was involved.

Table 8. Loss of sensitivity in the diagnosis of granulomatous lymphadenitis, taking into consideration the non-evaluation of all the chains of lymph nodes provided for in the current inspection line routine.

Change in the inspection routine	Loss of sensitivity	
	Breeder	Finisher
Examination of cervical lymph nodes only	(-) 93.18	(-) 80.18
Examination of mediastinal lymph nodes only	(-) 95.20	(-) 95.87
Examination of mesenteric lymph nodes only	(-) 8.08	(-) 13.98
Examination of mesenteric and mediastinal lymph nodes only	(-) 3.28	(-) 11.29

Maintaining only the mesenteric lymph node examination procedure (on the intestines line), 8.08% of detections are lost in breeder pigs, and 13.98% in finisher pigs. Taking into account a change in the head inspection procedure, in which the lymph nodes are removed intact, the record of the lesion is suppressed; however, there is no increase in the risk to the consumer. In fact, in accordance with current regulations, in 2.25% of cases of lesions exclusively of the mediastinal lymph nodes in finisher pigs, the record and intervention are lost. The currently recommended disposition for detection at a single site is as follows:

“Article 200. Carcasses of swine presenting localized lesions of granulomatous lymphadenitis limited only to a primary infection site, as in the cervical lymph nodes or mesenteric lymph nodes or mediastinal lymph nodes, but which are deemed fit for consumption, may be approved for consumption after the affected region or organ has been condemned”.

If inspection of the cervical and mediastinal lymph nodes is abolished, only 0.5% of concomitant occurrences between these two locations would produce a change in the disposition of the finisher pigs. However, if the digestive tract is deemed to be a single site, including cervical, mesenteric and mediastinal lymph nodes draining part of the esophagus, the lesion in two of these places would receive the same disposition as the carcass. It is concluded that no loss exists in regard to consumer protection by maintaining only the official intesti-

ne inspection line to detect granulomatous lymphadenitis. If lesions are found in mesenteric lymph nodes, the carcass, the head, and the set of corresponding viscera are to be railed out to the DIF for detailed examination of the carcass and reassessment of visceral lymph nodes by the official veterinarian.

Adherences

Analyzing the SIGSIF data for 2012-2014 (Coldebela et al., 2018), adherences were reported as the major cause of deviation/condemnation, coming to 3.72% of carcasses of swine slaughtered in Brazil. Most of the lesions found at slaughter are the chronic sequelae of bacterial infections that have not been listed in the prioritization of risks as posing a risk to consumers. Most of these carcasses presenting adherences of serosae in the thoracic cavity undergo sanitary dressing and are approved for human consumption. However, to meet international requirements that have been incorporated into Brazilian legislation (Ordinance 711/95), up until the publication of Ordinance 1,304 on 07/10/2018, no carcass entering the final veterinary reinspection department (DIF) may be approved for export: this disqualified the raw material from economically more profitable markets.

Thus, despite the fact that the causal agents of pleuritis, which evolves to adherences, are not hazards to human health, a study was carried out in order to confirm the hypothesis and enable decision-making, because adherences are the main cause of deviations/condemnations of the carcass. In this study, the presence of viable bacteria in chronic lesions of the pleura (adherences) in cases where the carcasses have been railed out to the DIF was investigated, and the microscopic characteristics of the lesions were examined. Pleurites (adherences) were identified on the inspection line and the carcasses were railed out to the Final Inspection Department (DIF) in accordance with the normal inspection criteria for a more detailed visual examination and sample-taking. The cases of pleuritis were classified visually in terms of their evolution towards chronic pleuritis, when there was a firm adhesion from the lung to the thorax without evidence of exudate from the lesion. In total, 100 carcasses were analyzed: 50 showed lesions of chronic pleuritis with an adjacent pulmonary lesion, and 50 showed chronic lesions without a pulmonary lesion. In order to obtain greater variability, a limit of a maximum of five samples from a single origin was established.

In the bacteriological test, all pleural samples returned negative, irrespective of the presence of an adjacent pulmonary lesion, showing the absence of bacteria in the adherences between the parietal and visceral pleurae. Bacterial isolation was only successful when based on the parenchyma with pneumonic lesions (74%), indicating that the bacterial agents are restricted to the lung. In the histopathological examination, only in two samples (2%) was there any divergence in the characteristics of the stage of evolution of the pleural lesion at macroscopic assessment, probably because they presented discrete focal exudation, not identified by the evaluator; both samples were negative to bacteriological examination of the pleura. The absence of viable bacteria in the chronic lesions (adherences) of the pleura, irrespective of a pulmonary lesion, without any repercussion for the carcass, and the histopathological results, support macroscopic evaluation as a reliable tool for decision-making as to the disposition of the carcass at the moment of inspection.

Other hazards

Brucella suis, which is classified as a very low-level hazard (Figure 2), is not suitably controlled at the slaughter of lots of swine coming from technology-intensive pig farming. *Brucella suis* causes a reproductive disease and its major route of transmission is genital: the target of control is to maintain breeder farms infection-free. Certified Pig Breeding Farms (GRSC - *Granjas de Reprodutores Suídeos Certificadas*) are regulated by Normative Instruction IN19 published in 2002, which demands twice yearly serological monitoring for brucellosis and mandatory notification of the disease. Brazil's National Program for the Control and Eradication of Animal Brucellosis and Tuberculosis (PNCEBT) has not presented positive data for swine brucellosis (personal communication). We therefore recommend that monitoring should remain for breeder herds, conducted by technically responsible veterinarians, so as to ensure sanitary pyramids free of brucellosis. The disease will thus be controlled both in animals and, as a result, in humans, addressing both the occupational and the foodborne risks.

Meat-borne erysipelas was classified as a low-level hazard (Figure 2). As a cause of carcass rejection, its frequency was only 808 in over 94 million slaughtered swine (Coldebela et al. 2018). The disease typically presents in three forms: acute septicemia with high fever, and characteristic lesions on the skin of a non-ambulatory animal; a sub-acute form with the same symptoms except that they are less severe; and the chronic form which can evolve with endocarditis, polyarthritis and occasionally with skin lesions (Opriessnig; Coutinho, 2019). Most of the symptoms of the disease, especially the acute and sub-acute forms, are detected at ante-mortem examination: the pre-requisite for the ante-mortem examination is that the hogs should be clean before undergoing it. Cases of septicemia will be addressed as determined in Riispoa. If skin lesions are detected on the slaughter line that were not observed at ante-mortem examination, as well as the chronic lesions that may be associated with erysipelas, they will be treated by the establishment under the inspection of the AFFA.

Summary of the biological hazards characterized by the quantitative risk analysis and the suggested official monitoring

Table 9 summarizes the hazards listed in the item on Recommendations for the application of risk-based inspection in swine slaughterhouses with on-site Brazilian Federal Inspection Service (SIF) and the approach recommended for official monitoring. Some programs are already in force, while others are being prepared.

Table 9. Biological hazards in accordance with characterization of risk and type of official monitoring recommended.

Risk characterization	Prioritized hazards	Type of official monitoring
Very high		<ul style="list-style-type: none"> Without hazards characterized as very high risk
High	<i>Salmonella</i> (non-typhoidal)	<ul style="list-style-type: none"> Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018. Program to Assess the Compliance of Animal Products (PACPOA) to assess for presence in products displayed for consumption Official verification of the establishment's performance in preventing fecal contamination. Verification of GMP, SSOP and HACCP
Medium		<ul style="list-style-type: none"> Without medium-risk hazards
Low	<i>Staphylococcus</i> sp.	<ul style="list-style-type: none"> Removal of head and examination in a separate room Program to Assess the Compliance of Animal Products (PACPOA) to assess for presence in products displayed for consumption Verification of GMP, SSOP and HACCP
Low	<i>E.coli</i>	<ul style="list-style-type: none"> Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 Official verification of the establishment's performance in preventing fecal contamination Verification of GMP, SSOP and HACCP
Low	<i>Campylobacter coli</i>	<ul style="list-style-type: none"> Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 Official verification of the establishment's performance in preventing fecal contamination Verification of GMP, SSOP and HACCP
Low	<i>Mycobacterium avium</i>	<ul style="list-style-type: none"> Post-mortem monitoring of mesenteric lymph nodes

Risk characterization	Prioritized hazards	Type of official monitoring
Low	<p><i>Arcobacter</i> sp. (<i>Enterobacter</i>)</p>	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP.
Low	<p><i>Toxoplasma gondii</i></p>	<ul style="list-style-type: none"> • No specific measure taken on the slaughter line. Competent authorities are recommended to perform studies to determine sources of <i>Toxoplasma gondii</i> infection in order to assess the importance of pork, compared to other foods, as a source of occurrence in humans
Low	<p><i>Yersinia enterocolitica</i></p>	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP
Low	<p><i>Listeria monocytogenes</i></p>	<ul style="list-style-type: none"> • Brazil's National Pathogen Control Program (PNCP) - Program for the Control of <i>Listeria monocytogenes</i> in ready-to-eat animal products.
Low	<p>Hepatitis E</p>	<ul style="list-style-type: none"> • No specific measure taken on the slaughter line • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 • Competent authorities are recommended to carry out studies to determine sources of hepatitis E virus infection in order to assess the importance of pork, compared to other foods, as a source of occurrence in humans • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP
Low	<p><i>Erysipelothrix rhusiopathie</i></p>	<ul style="list-style-type: none"> • Post-mortem visual monitoring

Risk characterization	Prioritized hazards	Type of official monitoring
Low	<i>Clostridium perfringens</i>	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 • Program to Assess the Compliance of Animal Products (PACPOA) to assess for presence in products (cooked meat) displayed for consumption • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP
Very low	<i>Balantidium coli</i>	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP
Very low	<i>Aeromonas</i> sp.	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP
Very low	<i>Yersinia pseudotuberculosis</i>	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP
Very low	Sarcosporidiose	<ul style="list-style-type: none"> • Post-mortem monitoring in breeders and competent agencies
Very low	Rotavirus	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction nº 60 dated 20/12/2018 • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP

Risk characterization	Prioritized hazards	Type of official monitoring
Very low	<i>Mycobacterium bovis tuberculosis</i>	<ul style="list-style-type: none"> • Post-mortem monitoring of intestinal lymph nodes
Very low	<i>Giardia</i> sp.	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction n° 60 dated 20/12/2018 • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP
Very low	<i>E.coli</i> (O157 H7)	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction n° 60 dated 20/12/2018 • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP
Very low	<i>Clostridium botulinum</i>	<ul style="list-style-type: none"> • Program for monitoring <i>Salmonella</i> sp. and enterobacteriaceae in swine carcasses brought in by Normative Instruction n° 60 dated 20/12/2018 • Official verification of the establishment's performance in preventing fecal contamination • Verification of GMP, SSOP and HACCP
Very low	Cisticercose/Tenilase	<ul style="list-style-type: none"> • Post-mortem monitoring in breeders
Very low	<i>Brucella suis</i>	<ul style="list-style-type: none"> • No specific measure taken on the slaughter line
Negligible in the population that was studied	<i>Trichinella spiralis</i>	<ul style="list-style-type: none"> • Commercial hog-raising exempt from monitoring. Communication of the risk of consumption of meat from feral hogs is suggested

Changes in procedures for the inspection and classification of pigs, carcasses and parts of carcasses

Scope of the project

The scope of the project is focused on establishments registered in the Federal Inspection Service (SIF) that slaughter swine from farms meeting the following conditions. They are:

- Technology-intensive, confinement-based, commercial producers of domesticated swine;
- Registered with the animal health service;
- Issue information on the raising of swine by means of the Sanitary Bulletin of the lot;
- Subject to veterinary control.

The results are limited to this scope and do not apply to other production and inspection systems or to backyard hogs and feral swine.

Ante-mortem inspection

Ante-mortem examination is performed by the official veterinarian in order to: evaluate information from the production chain; identify and segregate animals that need greater post-mortem attention; prevent the slaughter of animals that have been given unsuitable drug treatments; and also to ensure the execution of official sanitary surveillance programs for diseases such as foot and mouth disease and swine fever.

Classification of the lots of swine by their risk level helps the official veterinarian to provide guidance for ante-mortem and post-mortem inspection (Heinonen et al., 2001). When the information generated by the food production chain can be and has been evaluated. Brazil has an inspection chain covering all steps of agricultural and livestock production applied by a sin-

gle agency (Mapa), which facilitates the traceability of information throughout the production chain. The information includes data on the transportation and movement of animals, immunizations, feed additives, compliance with export requirements, and the use of therapeutic and prophylactic medications, and so on. However, data declared as “information from the food production chain” must be audited in order to verify its veracity and completeness, because in certain situations there may be low reliability for such data (Felin et al., 2016).

The responsible agency (Mapa) has a cross-cutting Residues and Contaminants Monitoring Program (PNCRC), horizontal pathogen reduction programs (PRP), and quality monitoring of end-products, all of which provide reliable data for the performance of epidemiological studies and the creation or adjustment of animal health and public health risk reduction strategies. Brazil also has a Swine Health Program (National Swine Health Program - PNSS) introduced by a Normative Instruction in 2004, which aims to provide sanitary control in establishments that raise, breed, sell and distribute swine and swine multiplication materials, and to prevent the introduction of exotic diseases and control or eradicate those diseases existing in the country. There are also instructions that address notifiable diseases, both exotic diseases and those under some kind of official control that were the object of study in this project.

The importance of the veterinary inspection carried out by the official service immediately prior to slaughter is therefore undeniable, because it guarantees that as a minimum the official evaluation is carried out on 86% of the swine slaughtered in the country. For 2017 this coverage accounted for 37,158,602 swine out of a total slaughter of 43,185,385 (IBGE, 2017: IBGE is Brazil's official statistical agency) which resulted from the production of 3.75 million tonnes of pork (ABPA, 2019).

In order to perfect the official ante-mortem activities, the most essential duties regarding the sanitary evaluation of lots of swine were verified. The examination is to focus on identifying the history or clinical detection of situations where there is any risk to public health, or that require attention from the official services because they involve suspected cases of notifiable diseases. The verification is based on the list of notifiable diseases published in Normative Instruction N° 50, dated September 24, 2013 (IN 50/2013), which amended the list of diseases amenable to the application of animal health protection mea-

asures set forth in Article 61 of the Regulations for the Animal Health Service as published by Decree no. 24,548 enacted July 3, 1934. All the diseases on the list were evaluated in terms of the potential for the detection of signs and symptoms at ante-mortem or post-mortem examination; the characteristics of their lesions were analyzed for macroscopic presumptive diagnosis.

Given the extent of the list of diseases cited in Normative Instruction (IN) 50/2013, a meeting was scheduled with the Department of Animal Health (DSA) in order to align the objectives of this inspection with animal health-related sanitary surveillance, and epidemiological information on the lots. The detection and notification of production-related diseases were excluded from the scope of the official service; the evaluation of hemorrhagic, nerve and vesicular syndromes remained. Based upon this information, the present project suggests passing to the technically-responsible Veterinarian (RV) the competent jurisdiction for the detection and treatment of production-related diseases, and of possible lesions that might lead to sanitary compromise of the slaughter from a public-health point of view.

SIGSIF does not provide a “statistical map” for reporting the lesions and diagnoses from ante-mortem; thus, the history of lesions, of animal health notifications, and of any detected infringements such as the use of banned drugs, lies outside the systematic records accessible by higher authorities. Improvements are therefore indicated in the record-keeping system to encompass the information from the ante-mortem inspection.

Chart 2 presents the objectives and procedures laid down in Ordinance 711/95 and the adjustments to be made. Suggestions concerning the procedures to be implemented under risk-based inspection are listed and justified for each objective.

Chart 2. Biological hazards in accordance with characterization of risk and type of official monitoring recommended.

Objective/procedure	Suggestions issued by the project
<ul style="list-style-type: none"> Evaluate animal health sanitary certificates (GTA/ Sanitary Bulletin). Check the number of animals presented on the following day's itemized or overall slaughter schedule, as provided to the SIF by the company, as laid down in the legislation. 	<ul style="list-style-type: none"> The responsible veterinarian (RV) evaluates production chain (pre-slaughter) information and takes measures accordingly, preferably prior to loading. Audit by the AFFA as per sampling defined by the risk-manager. The count of hogs will be a duty of the establishment because there is no sanitary issue involved. The corrections needed in order to make adjustments to the documentation or the remaining balance on the farms must be carried out by the RV prior to the approval of the lots for slaughter. When applicable, the removal of the GTA from animal health systems in the States will be the responsibility of the RV.
<ul style="list-style-type: none"> The AFFA performs ante-mortem inspection twice for each lot, at the moment of unloading of the hogs into the sties, and moments before the slaughter. Examine the health condition of the swine and assist the post-mortem inspection task by providing informative data. Overall visual examination, carefully observing the animals' behavior, placing those that require an individual examination for any sanitary reason, in the holding pen. 	<ul style="list-style-type: none"> The RV is to train personnel to detect and segregate animals bearing lesions at the receiving and separating steps of unloading. The AFFA is to oversee the segregation procedures performed under the orientation of the RV, in weekly sample-based audits. The AFFA is to perform the ante-mortem inspection of animals that have been separated as a result of this assessment, confirming or changing the disposition given by the RV. The AFFA is to perform the ante-mortem inspection of all lots deemed fit by the establishment, keeping a focus on the evaluation of diseases of animal health concern and diseases in the lot that could be important for the post-mortem.

Objective/procedure	Suggestions issued by the project
<ul style="list-style-type: none"> Inspect the animals as in motion during the unloading process, as well as in repose in the sties, and once again in motion in the sties. 	<ul style="list-style-type: none"> The study that was carried out showed that the evaluation of animals in motion is more sensitive than the evaluation of animals in repose. The most frequently detected lesions are consequences of tail biting, and those of the locomotor apparatus, which can be detected by the RV (or other trained staff) at the unloading of the animals. Additionally, there is a visible increase in the animals' stress owing to the motion. Lesions and clinical signs of official interest, including dyspnea, are detected with the animals in repose.
<ul style="list-style-type: none"> Send animals to segregation that have infectious, parasitic or non-specific diseases. Segregated hogs are identified and always slaughtered separately (emergency slaughter). 	<ul style="list-style-type: none"> The RV will order the segregation of animals prevented from being slaughtered either due to explicit rules in the legislation or due to their being a potential source of contamination of the process. Audit by the AFFA as per sampling defined by the risk-manager.
<ul style="list-style-type: none"> Reject any sows when a recent delivery or miscarriage are diagnosed. 	<ul style="list-style-type: none"> The RV will order the segregation of animals prevented from being slaughtered either due to explicit rules in the legislation or due to their being a potential source of contamination of the process. Audit by the AFFA as per sampling defined by the risk-manager.
<ul style="list-style-type: none"> Animals condemned at ante-mortem inspection will be euthanized in the necropsy room (hyperthermia or hypothermia, caechexia and other causes). 	<ul style="list-style-type: none"> We suggest adjusting the animal welfare rules so that animals receiving a severe trauma during transport may be euthanized while still on the vehicle, minimizing their suffering. At the discretion of the RV these animals may be euthanized even if the AFFA is not present, provided that the RV issues a certificate of the absence of signs of hog-population diseases of public health concern. Pursuant to determination by the AFFA, the carcasses and viscera of euthanized animals may remain in the necropsy room until the AFFA has assessed them.

Objective/procedure	Suggestions issued by the project
<ul style="list-style-type: none"> • Use of ante-mortem information as underpinning for the post-mortem examination diagnosis. 	<ul style="list-style-type: none"> • When evaluating the information flows during the pilot projects, the need to use shared electronic records became clear. They enable lot data to be made available by the farm TR during the raising phase, generating a history that can be assessed at ante-mortem inspection. It was observed that the manual completion of data could lead to transcription errors being made, compromising the reliability of the farm documents, and mistakes being made in entering the information into the system. Manual recording on forms allows lesions found on a single animal/carcass to be entered independently, leading to duplicated data recording. SIGSIF does not allow the results of the classification lines and total/partial condemnations to be provided per farm. The use of electronic records is fundamental for producing reliable data and allows the establishment to enter the data and ensures traceability back to the farm of origin. To this end it is essential to maintain identification of lots/loads by tattoos, to add individual identification of the animals when separated in the sties, and to include sequential numbering of the carcasses at slaughter. The position on the slaughter line for numbering the carcasses must be upstream of the location intended for the first inspection by the AFFA, in order to guarantee the traceability of the information.
<ul style="list-style-type: none"> • When necessary, verify the weight, breed, classification and origin, allowing for the obtaining of data for possible economic or husbandry studies. 	<ul style="list-style-type: none"> • Eliminate from the mandatory controls at the live animal receiving step, preserving on the system the information demanded by the Risk Manager.

Objective/procedure	Suggestions issued by the project
<ul style="list-style-type: none"> To check animal welfare conditions and the hygiene and preservation conditions of the pens, as well as the provision of water in the drinking troughs, taking the required measures to correct it, if necessary. 	<ul style="list-style-type: none"> We suggest that hygiene and welfare verifications are given space in the regulations governing these matters.
<ul style="list-style-type: none"> Whenever foot and mouth disease and swine fever are found at ante-mortem inspection, the entry of swine must be suspended until the lairage sties are empty and properly disinfected, and the competent sanitary authority must be notified of what has happened. 	<ul style="list-style-type: none"> We suggest suppressing this a referencing the rules of the Department of Animal Health.

Procedures proposed by risk-based inspection for the ante-mortem inspection

a) Responsible Veterinarian assesses the farm information in advance taking the objectives into consideration:

- Assess compliance with the drugs' withdrawal periods, and whether medications approved by the legislation (and recommended by the self-control programs) have been used and take corrective actions prior to transportation of the animals to slaughter.
- Assess the clinical history of the animals prior to loading and, if necessary, notify the sector responsible in order to suspend the loading operation.
- Identify the origin of the animals and the production chain information (traceability and compliance with domestic and international requirements).
- Complete the records of this evaluation and of any measures taken in the event of deviations, leaving the information available at the pen for the official veterinarian (AFFA) to consult at ante-mortem.

b) Reception, identification and classification of the animals in the lairage sties, by the classifiers:

- As instructed by the RV and in compliance with the legislation: assess, identify and isolate in the observation pen any animals showing tail biting lesions, fractures, skin lesions, hernias, and so on; clinical signs such as apathy, prostration, non-ambulatory status and so on, as well as behavior changes. These animals are to be clinically evaluated by the AFFA.
- Separate those animals that are dead on arrival, and have them taken to the necropsy room to be examined by the AFFA. Animals showing signs of post-death changes will not be examined by the AFFA; however, to make up the lot history, records are to be taken.
- Identify any animals in distress which need to be euthanized immediately (in accordance with criteria defined in the self-control program) or undergo necropsy. Animals slaughtered outside the slaughter period

are compulsorily to be deemed unfit for consumption. In such cases the slaughter is to be accompanied by the classifier, and the RV is to issue a declaration containing the animal's identification, and the cause of the procedure, within the scope of animal welfare. In the case of a necropsy, the cadaver must be available for the AFFA to audit the procedure.

- Identify segregated animals with a sequential number.
- Take records on the form.
- Take steps to address non-compliances of transportation, involving the state-level animal health authority (such as animals traveling without a GTA, or an animal movement declaration not matching the total number of animals given on the GTA) in accordance with the procedures and systems available in each state-level animal health executive authority.
- Place any animals showing lesions compatible with vesicular, hemorrhagic or nervous syndromes under segregation, and call in the RV for an immediate veterinary assessment. If a notifiable disease subject to official monitoring is suspected, the RV should issue the notification allowed for in Normative Instruction 50/2013 and inform the AFFA of this.

c) Ante-mortem inspection by an AFFA who has graduated in Veterinary Medicine:

- Assess the documentation of the lots and take actions in the event of possible failures in prior inspection by the RV, or failure in the action recommended to the slaughter establishment by the RV.
- Perform a clinical examination of all segregated animals, confirming or restricting the proposed dispositions (immediate slaughter, delayed slaughter, necropsy) for the held animals.
- Define those lots that will need to be slaughtered and evaluated with the highest degree of attention, defining which animals will be taken to the DIF.

- Assess the lots of animals that have been visually identified (by the use of signs and of auditable records on the lairage pens) as being classified as fit for slaughter: in repose, moving them only at the discretion of the AFFA, and take steps if there are failures in the classification.
- Authorize lots for slaughter (following the visual identification of approval given by the Official Service).
- Necropsy the dead animals assisted by the establishment classifier, with the aid of a trained establishment employee.
- Record - on the form entitled MOAM01B (until the electronic form becomes available) - the approval for slaughter of lots.
- Take the animal health actions that are the responsibility of the official service in the event of identification of suspected cases of diseases that are monitored by official programs, such as foot and mouth disease, classical swine fever, and others. If the RV has not notified the Animal Health Service, do so using the appropriate form.

Post-mortem inspection

From the results obtained at previous steps of the project, information was cross-checked in order to link each inspection line with more frequent detections; the classification of these detections; the percentage of condemnations related to detection; the possible hazards involved; the risk attributed to the hazards and the interpretation in terms of the indication of the problem related to the recorded detection (Table 10). The following factors were deemed of significant frequency for the study: lesions that occur at a percentage greater than or equal to 0.1% of the total number of swine slaughtered (Table 1); and lesions whose classification as entered into the system is characteristic of zoonoses (Table 2).

Table 10. Links between detections on the inspection lines and the hazards involved, with an indication of the problem related to the detection.

Line/viscera	Detection	Classification	Condemnation (%)	Hazards involved	Risk	Problem
A1 - Head, and lymph nodes of jowl	Contamination	Technopathy (lesion caused by failure in the slaughter processing)	2.1102	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Aerobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: H7), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp.	High	Hygiene failures in the evisceration process
	Granulomatous lymphadenitis		0.0004	<i>Mycobacterium avium</i>	Low	Infection on the farm
	Cysticercosis	Hazard-related	0.00001	<i>Mycobacterium bovis/tuberculosis</i>	Very low	Infection on the farm
	Sarcosporidiosis		0.000004	<i>Cysticercus cellulosae</i>	Very low	Infection on the farm
B - stomachs	Contamination	Technopathies	0.8735	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Aerobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: H7), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp.	High	Hygiene failures in the evisceration process
	Parasitosis	Non-zoonotic parasitosis	0.0139	Not Identified		
	Granulomatous lymphadenitis	Hazard-related	0.0389	<i>Mycobacterium avium</i> <i>Mycobacterium bovis/tuberculosis</i>	Low	Infection on the farm
					Very low	

Line/viscera	Detection	Classification	Condemnation (%)	Hazards involved	Risk	Problem
B - spleens	Contamination	Technopathies	2.4361	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Arcobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: H7), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp.	High	Hygiene failures in the evisceration process
	Congestion	Non-specific*	0.5319	Not Identified		
	Splenitis	Non-specific*	0.4437	Not Identified		
B - intestines	Contamination	Technopathies	3.9660	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Arcobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: H7), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp.		
	Enteritis	Non-specific*	1.1760	Not Identified		
	Parasitosis	Non-zoonotic parasitosis	0.0924	Not Identified		
	Granulomatous lymphadenitis	Hazard-related	0.1960	<i>Mycobacterium avium</i> <i>Mycobacterium bovis/tuberculosis</i>	Low Very low	Infection on the farm

*Referring to acute or chronic lesions associated with infectious agents normally present in hog-raising and not related to zoonotic issues.

Line/viscera	Detection	Classification	Condemnation (%)	Hazards involved	Risk	Problem
C - hearts	Contamination	Technopathies	2.2972	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Arcobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: HT), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp	High	Hygiene failures in the evisceration process
	Pericarditis	Non-specific*	5.7512	Not Identified		
	Cysticercosis	Hazard-related	0.0007	<i>Cysticercus cellulosae</i>	Very low	Infection on the farm
	Endocarditis	Hazard-related	0.0002	<i>Streptococcus suis</i> <i>Erysipelothrix rhusiopathiae</i>	Low	Infection on the farm
	Contamination	Technopathies	2.6372	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Arcobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: HT), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp	High	Hygiene failures in the evisceration process
C - tongues	Abscess	Non-specific*	0.0285	Not Identified		
	Cysticercosis	Hazard-related	0.000016	<i>Cysticercus cellulosae</i>	Very low	Infection on the farm
	Sarcosporidiosis	Hazard-related	0.000001	<i>Sarcocystis</i> sp.	Very low	Infection on the farm

*Referring to acute or chronic lesions associated with infectious agents normally present in hog-raising and not related to zoonotic issues.

Line/viscera	Detection	Classification	Condemnation (%)	Hazards involved	Risk	Problem
D - livers	Contamination	Technopathies	2.6650	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Arcobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: H7), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp	High	Hygiene failures in the evisceration process
	Perihepatitis	Non-specific*	4.4807	Not Identified		
	Larval migration	Parasitoses	3.9117	Not Identified		
	Congestion	Metabolic/technopathies	2.6361	Not Identified		
	Steatosis	Metabolic	0.8605	Not Identified		
	Hepatitis	Hazard-related	0.0342	Hepatitis E	Low	
	Asphyxia		4.1272	Not Identified		
	Aspiration of blood		3.4485	Not Identified		
	Aspiration of water		2.4456	Not Identified		Animal welfare
	D - lungs	Contamination	Technopathies	2.4457	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Arcobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: H7), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp.	High

*Referring to acute or chronic lesions associated with infectious agents normally present in hog-raising and not related to zoonotic issues.

Line/viscera	Detection	Classification	Condemnation (%)	Hazards involved	Risk	Problem
D - lungs	Enzootic pneumonia (pulmonary consolidation)		6.5361	Not Identified		
	Emphysema		5.5715	Not Identified		
	Atelectasis		1.0163	Not Identified		
	Congestion		3.1905	Not Identified		
	Pneumonia	Non-specific*	0.7679	<i>Pasteurella multocida</i> <i>Actinobacillus pleuropneumoniae</i> <i>Streptococcus suis</i> <i>Actinobacillus suis</i>	Non-prioritized	
	Adhesion		0.4589	Absence of viable pathogens, the adhesions of the serosae are the sequelae of clinical pictures that have resolved		
	Pleuritis		0.1944	<i>Pasteurella multocida</i> <i>Actinobacillus pleuropneumoniae</i> <i>Haemophilus parasuis</i> <i>Mycoplasma hyorhinis</i>	Non-prioritized	
	Parasitosis	Non-zoonotic parasitosis	0.0947	Not Identified		
	Granulomatous lymphadenitis	Hazard-related	0.0374	<i>Mycobacterium avium</i> <i>Mycobacterium bovis/tuberculosis</i>	Low Very low	Infection on the farm

*Referring to acute or chronic lesions associated with infectious agents normally present in hog-raising and not related to zoonotic issues.

Line/viscera	Detection	Classification	Condemnation (%)	Hazards involved	Risk	Problem
F - kidneys	Contamination	Technopathies	2.4314	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Arcobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: HT), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp.	High	Hygiene failures in the evisceration process
	Urinary cyst		4.7694	Not Identified		
	Nephritis		4.4701	Not Identified		
	Congestion	Non-specific*	1.1416	Not Identified		
	Uronephrosis		0.7551	Not Identified		
	Anemic infarct		0.6052	Not Identified		
E/DIF - Carcasses	Adhesion	Non-specific*	3.7205	Absence of viable pathogens, the adherences of serosae are sequelae of clinical pictures that have resolved		
	Contamination	Technopathies	1.7967	<i>Salmonella</i> (non-typhoidal), <i>Escherichia coli</i> , <i>Campylobacter coli</i> , <i>Arcobacter</i> sp., <i>Yersinia enterocolitica</i> , <i>Clostridium perfringens</i> , <i>Yersinia pseudotuberculosis</i> , <i>Clostridium botulinum</i> , <i>Escherichia coli</i> (O157: HT), <i>Balantidium coli</i> , Rotavirus and <i>Giardia</i> sp.	Alto	Hygiene failures in the evisceration process
	Bruising	Technopathies	1.2894	Not Identified		Animal welfare
	Pleuritis	Non-specific*	0.8483	Not Identified		
	Abscess	Non-specific*	0.5800	Not Identified		

*Referring to acute or chronic lesions associated with infectious agents normally present in hog-raising and not related to zoonotic issues.

Line/viscera	Detection	Classification	Condemnation (%)	Hazards involved	Risk	Problem
	Traumatic	Technopathies	0.2771	Not identified		Animal welfare
	Granulomatous lymphadenitis	Hazard-related	0.2904	<i>Mycobacterium avium</i> <i>Mycobacterium bovis/tuberculosis</i>	Low Very low	Infection on the farm
	Pneumonia	Non-specific*	0.1968	<i>Pasteurella multocida</i> <i>Actinobacillus pleuropneumoniae</i> <i>Haemophilus parasuis</i>	Non-prioritized	
	Cryptorchidism	Non-specific*	0.1494	Not identified		
	Mange	Parasites	0.1362	Not identified		
	Suppurated lesion	Non-specific*	0.1291	Not identified		
	Excess scalding	Technopathies	0.1170	Not identified		
	Peritonitis	Non-specific*	0.1012	Not identified		
E/DIF - carcaças	Erysipelas	Hazard-related	0.0009	<i>Erysipelothrix rhusiopathiae</i>	Low	Infection on the farm
	Cysticercosis	Hazard-related	0.0001	<i>Cysticercus cellulosae</i>	Very low	Infection on the farm
	No	Not identified	0.0000	<i>Trichinella spiralis</i>	Non-prioritized	
	No	Not identified	0.0000	<i>Toxoplasma</i>	Low	Infection on the farm
	No	Not identified	0.0000	<i>Staphylococcus</i> sp.	Low	

* Referring to acute or chronic lesions associated with infectious agents normally present in hog-raising and not related to zoonotic issues.

The recommendations of the working group took into consideration the responsibility of the producing establishment to make food within the minimum standards of quality and in compliance with the legislation. The producing establishment must therefore deem those viscera, carcasses and parts of carcasses where there is visible change to any tissue to be unfit, as is, for consumption, whenever they do not meet the minimum quality specifications expected for the meat: in other words, the edible part of the carcasses of healthy animals slaughtered under inspection.

After the evaluation of each examination that is being performed on the inspection lines in accordance with current regulations, it was possible to identify which lesions were correlated to significant public health hazards, and what was the best action strategy for the official service to control these hazards. Each of the lines therefore had its procedures adjusted, by: the goal of assessment, the public health significance of the diagnosis, and the comparison of the control measure to the possibility of increasing or reducing the hazard as a result of handling and cutting. Upon completion of the evaluation it was possible to recommend the following:

- Canceling the need for the inspection or classification of the carcass part or viscera.
- Maintaining inspection or classification while eliminating some incision, palpation or visualization procedures.
- Activities and information of interest to the official service were listed, as indicated by the scope of risk-based post-mortem inspection, on the inspection line and in the DIF.
- The following official service activities were removed from the scope of their duties: the classification of viscera, carcasses and parts of carcasses not involving identification of public health hazards but which evaluate compliance with quality specifications, and these now constitute part of the classification procedures on the lines and examination by the RV in the Supplementary Examination Department (DEC).

In turn, the official service is to evaluate the execution of this classification activity and whether it complies with the requirements of regulations and the technical consistency of the actions planned by the company, by sampling audits, at strategic points defined by the official service itself. The appropriate actions will be taken whenever quality failures are detected.

Especially noteworthy is the change in official action in the event of contamination of the pork by gastrointestinal microorganisms, for which an alteration in responsibilities is proposed. The company is to assume self-control in order to avoid as far as possible the occurrence of points of contamination, and to monitor and address visibly detectable contamination; while the official service is to audit the compliance of these controls with legal provisions, taking process- and product-related actions in the event of repeated failures in the self-controls. To support local visual evaluation, the producing establishment is also to possess the specific microbiological controls laid down in Normative Instruction no. 60, dated December 20, 2018.

Table 11 presents the decision-making matrix for defining whether to maintain or extinguish procedures and defining whether to ascribe activities to the inspection duties of the official service or to classification by the Responsible Veterinarian.

Table 11. Decision-making matrix for defining whether to maintain or extinguish procedures and defining whether to ascribe to the inspection duties of the Official Service or to classification by the Responsible Veterinarian (RV), by animal category (Finishers and Breeders).

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible procedure recommended	Summary of scientific opinion	Reference of justification
F/B	A1	Head (adjacent muscles and tissues)	Zoonotic (zootic)	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Classification and treatment of the contaminated part (product) and of the cause of contamination (process) by RV. AFFA audit of classification procedures. Minimization of exposure of tissues and rupture of muscle and lymph tissues. Monitoring program to evaluate process hygiene on carcass. Hazards potentially present are mitigated by treatment of head and tongue. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by contamination of gastrointestinal contents. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process- and product-related actions.
F	A1	Head (adjacent muscles and tissues)	Zoonotic parasitoses (<i>Cysticercus cellulosae</i> and <i>Sarcocystis</i> sp.)	NI**	NI**	NI**	NI**	No	No	<ul style="list-style-type: none"> Training of operators to identify possible hazards at other steps of the process. 	<ul style="list-style-type: none"> Hazard assessed as being very low risk Extremely low frequency of detection on the lines (Table 2). Negligible frequency of detection in the one-year prospective study (Table 5).

NI**= Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
B	A1	Head (adjacent muscles and tissues)	Zoonotic parasitoses (<i>Sarcocystis</i> sp.)	NI**	NI**	X	X	Yes	No	<ul style="list-style-type: none"> Maintain examination of cuts on the lines, for the detection, segregation and treatment of products. Field department/grower notify when biosecurity actions are taken on the farm. 	<ul style="list-style-type: none"> Hazard assessed as being very low risk. Extremely low frequency of detection on the lines (Table 2). Detection occurred and there was significant confirmation of diagnoses by the prospective trial (Table 5) in breeders.
F/B	A1	Jowl lymph tissues	Granulomatous lymphadenitis (<i>Mycobacterium</i> sp.)	Audit	NI**	NI**	NI**	No	No	<ul style="list-style-type: none"> Maintain evaluation only of mesenteric lymph nodes. When detected in mesenteric lymph nodes - the heads, viscera and carcasses are railed out to the DJF for evaluation of other lymph nodes and suitable disposition. Minimization of exposure of tissues and rupture of muscle and lymph tissues. Hazards potentially present are mitigated by treatment of head and tongue. 	<ul style="list-style-type: none"> Low and very low-risk hazards. Uncertainty of the importance of pork in the human infection chain. Handling and opening head tissues and exposure of the tongue may amplify the higher-risk hazards present in the tissues. Detection mainly of lymphadenitis in cuts of mesenteric lymph nodes (76% in finisher pigs). Loss of sensitivity less than 15%.

NI**= Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
F/B	A1	Heads (adjacent muscles and tissues)	Non-specific lesions or those without repercussions for the carcass, and notifiable diseases (syndromes) only identified at PM*	N **	N **	N **	N **	No	Yes	<ul style="list-style-type: none"> Responsible veterinarian coordinates classification into fit / not fit for consumption. If there is a lesion of viscera comprising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV. AFFA audit of classification procedures. Training of growers, field operatives and slaughter operators to identify suspect cases and perform mandatory notification (vesicles). 	<ul style="list-style-type: none"> As demais lesões detectadas nas linhas não se apresentaram como indicativas de zoonoses ou de doenças de saúde animal. Segundo os depoimentos de AFFAs, as vesículas não são facilmente observáveis após a escaldagem, sendo a recepção dos animais e a mesa de sangria os locais mais apropriados para o exame.
F/B	C	Tongues	Gastrointestinal (zoonotic) microorganisms	X	N **	N **	N **	No	Yes	<ul style="list-style-type: none"> Does not possess any specific line; assessed as part of the head-jowl-tongue set. Classification and treatment of the contaminated part (product) and of the cause of contamination (process) by RV. AFFA audit of classification procedures. Minimization of exposure of tissues and rupture of muscle and lymph tissues. Monitoring program to evaluate process hygiene on carcass. Hazards potentially present are mitigated by treatment of head and tongue. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by contamination of gastrointestinal contents. Contamination owing to rupture of gastrointestinal tracts may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process- and product-related actions.

*PM= post-mortem examination.

N|**= Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
F	C	Tongues	Zoonotic parasites (<i>Cysticercus cellulosae</i> and <i>Sarcocystis</i> sp.)	NI**	NI**	NI**	NI**	No	No	<ul style="list-style-type: none"> • Training of operators to identify possible hazards at other steps of the process. 	<ul style="list-style-type: none"> • Hazard assessed as being very low risk. • Extremely low frequency of detection on the lines (Table 2). • Negligible frequency of detection in the one-year prospective study (Table 5).
B	C	Tongues	Zoonotic parasites (<i>Sarcocystis</i> sp.)	NI**	NI**	X	X	Yes	No	<ul style="list-style-type: none"> • Maintain examination of cuts on the lines, for the detection, segregation and treatment of products. • Field department/grower notify when biosecurity actions are taken on the farm. 	<ul style="list-style-type: none"> • Hazard assessed as being very low risk. • Extremely low frequency of detection on the lines (Table 2). • Detection occurred and there was significant confirmation of diagnoses by the prospective trial (Table 5) in breeders.
F/B	C	Tongues	Non-specific lesions or those without repercussions for the carcass, and notifiable diseases (syndromes) only identified at PM*	NI**	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> • Does not possess any specific line; assessed as part of the head-jowl-tongue set. • The RV coordinates the classification into fit / not fit for consumption. • If there is a lesion of viscera compromising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV. • AFFA audit of classification procedures. • Training of growers, field operatives and slaughter operators to identify suspect cases and perform mandatory notification (vesicles). 	<ul style="list-style-type: none"> • Remaining lesions detected on the inspection lines were not indicative of zoonoses or animal-health diseases. • AFFAs have reported that the vesicles are not easily identified after scalding; the receiving step and the bleeding table are the most suitable locations for the examination.

*PM= post-mortem examination.
NI**= Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible	line procedure recommended	Summary of scientific opinion	Reference of justification
F/B	C	Hearts	Gastrointestinal (zoonotic) microorganisms	X	NI**	NI**	NI**	No	Yes		<ul style="list-style-type: none"> Classification and treatment of the contaminated part (product) and of the cause of contamination (process) by RV. AFFA audit of classification procedures. Monitoring program to evaluate process hygiene on carcass. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by gastrointestinal content contamination. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process- and product-related actions.
F/B	C	Hearts	<i>Streptococcus suis</i> <i>Erysipelothrix rhusopathiae</i> Influenza	NI**	NI**	X	X	No	Yes		<ul style="list-style-type: none"> Cut open the heart in order to assess the interior. In the event of a vegetative endocarditis lesion rail out to DEC. 	<ul style="list-style-type: none"> Low and very low-risk hazards. Cases of endocarditis are not caused exclusively by the hazards listed, and the fact that they are detected with a very low frequency (Table 2) does not suggest that the slaughter line is the best point for official intervention. In the case of erysipelas, the skin lesions dispense with confirmatory laboratory testing. For the examination in the DEC, the RV may supplement it by confirmatory sampling and notify the farmer/technically responsible individual of the findings.

NI**= Not indicated.

Finisher/ Breeder	Line	Part/Viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
F	C	Hearts	Parasitoses zoonóticas (<i>Cysticercus cellulosae</i> e <i>Sarcocysts</i> sp)	X	NI**	NI**	NI**	No	No	<ul style="list-style-type: none"> • Training of operators to identify hazards at other steps of the process. 	<ul style="list-style-type: none"> • Hazards assessed as being very low risk. • Extremely low frequency of detection on the lines (Table 2). • Negligible frequency of detection in the one-year prospective study (Table 5).
B	C	Hearts	Parasitoses zoonóticas (<i>Sarcocysts</i> sp.)	NI**	NI**	X	X	Yes	No	<ul style="list-style-type: none"> • Maintain examination of cuts on the lines, for the detection, segregation and treatment of products. • Field department/grower notify when biosecurity actions are taken on the farm. 	<ul style="list-style-type: none"> • Hazard assessed as being very low risk. • Extremely low frequency of detection on the lines (Table 2). • Detection occurred and there was significant confirmation of diagnoses by the prospective trial (Table 5) in breeders.
F/B	C	Hearts	Lesões inespecíficas com ou sem reflexo na carcaça obrigatoria (síndromes) somente identificáveis no PM	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> • The RV coordinates the classification into fit / not fit for consumption. • If there is a lesion of viscera compromising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV. • AFFA audit of classification procedures. 	<ul style="list-style-type: none"> • Remaining lesions detected on the inspection lines were not indicative of zoonoses or animal-health diseases.

*PM= post-mortem examination.

NI**=Not indicated.

Finisher/ Breeder	Line	Part/Viscus	Group of related hazards and objective of the inspection procedure	Maintain Visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
F/B	B	Intestines	Gastrointestinal (zoonotic) microorganisms	NI**	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Classification and treatment of the contaminated part (product) and of the cause of contamination (process) by RV. AFFA audit of classification procedures. Minimization of exposure of tissues and rupture of muscle and lymph tissues. Monitoring program to evaluate process hygiene on carcass. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by gastrointestinal content contamination. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process- and product-related actions.
F/B	B	Intestines	Granulomatous lymphadenitis (<i>Mycobacterium</i> sp.)	NI**	NI**	X	NI**	Yes	No	<ul style="list-style-type: none"> Maintain evaluation only of mesenteric lymph nodes. When detected in mesenteric lymph nodes - the heads, viscera and carcasses are railed out to the DJF for evaluation of other lymph nodes and suitable disposition. Minimization of exposure of tissues and rupture of lymph tissues. 	<ul style="list-style-type: none"> Low and very low-risk hazards. Uncertainty of the importance of pork in the human infection chain. Handling and opening head tissues and exposure of the tongue may amplify the higher-risk hazards present in the tissues. Detection mainly of lymphadenitis in cuts of mesenteric lymph nodes (76% in finisher pigs). Loss of sensitivity less than 15%.

NI**= Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain Visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
F/B	B	Intestines	Non-specific lesions or those without repercussions for the carcass, and notifiable diseases (syndromes) only identified at PM*	X	X		NI**	No	Yes	<ul style="list-style-type: none"> The RV coordinates the classification into fit / not fit for consumption. If there is a lesion of viscera comprising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV. AFFA audit of classification procedures. 	<ul style="list-style-type: none"> Remaining lesions detected on the inspection lines were not indicative of zoonoses of animal-health diseases.
F/B	D	Livers	Gastrointestinal (zoonotic) microorganisms	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by gastrointestinal content contamination. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process - and product-related actions. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by gastrointestinal content contamination. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process - and product-related actions.

*PM = post-mortem examination.

NI** = Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
F/B	D	Livers	Hepatitis E (Hepatitis/Erhepatitis)	NI**	NI**	NI**	NI**	No	No	<ul style="list-style-type: none"> Impossible to visually monitor on the lines to detect the hazard. Livers classified as either fit or unfit for consumption. If there is involvement of the carcass, it, and the set of viscera and parts, will be railed out to the DEC. AFFA audit of classification procedures. 	<ul style="list-style-type: none"> Swine may be reagents and not harbor the virus. Swine may be asymptomatic carriers. The inspection line is not the appropriate point for controlling the hazard since the visual examination of the liver has no correlation to the presence of virus. Serology results and effective (on-going) detection of the Hepatitis E virus in the samples in order to continue the studies.
F/B	D	Livers	Non-specific lesions or those without repercussions for the carcass, and notifiable diseases (syndromes) only identified at PM*	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> The RV coordinates the classification into fit / not fit for consumption. If there is a lesion of viscera comprising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV. AFFA audit of classification procedures. 	<ul style="list-style-type: none"> Remaining lesions detected on the inspection lines were not indicative of zoonoses of animal-health diseases.

*PM= post-mortem examination.

NI**=Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible	line procedure recommended	Summary of scientific opinion	Reference of justification
F/B	D	Lungs	Gastrointestinal (zoonotic) microorganisms	X	NI**	NI**	NI**	No	Yes		<ul style="list-style-type: none"> Classification and treatment of the contaminated part (product) and of the cause of contamination (process) by RV. AFFA audit of classification procedures. Monitoring program to evaluate process hygiene on carcass. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by gastrointestinal content contamination. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process- and product-related actions.
F/B	D	Lungs	Welfare indicators (quality of stunning and slaughter)	X	NI**	NI**	NI**	No	Yes		<ul style="list-style-type: none"> Visual classification with an optional incision where there is a need for confirmation of the diagnosis. If aspiration of scalding water is suspected, there must be notification so that the stunning and bleeding processes can be assessed and appropriate corrections made to the process. 	<ul style="list-style-type: none"> Aspiration of scalding water is indicative of inhalation during the death throes of the animal during scalding – failure of animal welfare.

NI**= Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
F/B	D	Lungs	Non-specific lesions or those without repercussions for the carcass, and notifiable diseases (syndromes) only identified at PM*	NI**	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> The RV coordinates the classification into fit / not fit for consumption. If there is a lesion of viscera compromising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV. AFFA audit of classification procedures. 	<ul style="list-style-type: none"> Remaining lesions detected on the inspection lines were not indicative of zoonoses of animal-health diseases.
CARCASS GRADING											
F/B	E	Carcasses	Gastrointestinal (zoonotic) microorganisms	NI**	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Classification and treatment of the contaminated part (product) and of the cause of contamination (process) by RV. Small contaminations may be removed on the line maintaining monitoring of 100% of the carcasses. Monitoring program to evaluate process hygiene on carcass. AFFA audit of the establishment's classification procedures and microbiological controls. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by contamination of the gastrointestinal contents. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process- and product-related actions.

*PM= post-mortem examination.

NI**= Not indicated.

Finisher/ Breeder	Line	Part/Viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
T/R	E	Carcasses	Welfare indicators (quality of stunning and slaughter)	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Classification on the lines is coordinated by the RV in order to detect and treat lesions. Information is used in order to identify failures in the welfare program within the scope of raising, transportation and slaughter. Traceability of information back to the farm. 	<ul style="list-style-type: none"> Animal welfare is inspected by the official service.
F	E	Carcasses	Zoonotic parasites (<i>Cysticercus cellulosae</i> and <i>Sarcocystis</i> sp.)	NI**	NI**	NI**	NI**	No	No	<ul style="list-style-type: none"> Training of operators to identify possible hazards at other steps of the process. 	<ul style="list-style-type: none"> Hazard assessed as being very low risk. Extremely low frequency of detection on the lines (Table 2). Negligible frequency of detection in the one-year prospective study (Table 5).
B	E	Carcasses	Zoonotic parasites (<i>Sarcocystis</i> sp.)	NI**	NI**	X	X	Yes	No	<ul style="list-style-type: none"> Maintain examination of cuts on the lines, for the detection, segregation and treatment of products. Field department/grower notify when biosecurity actions are taken on the farm. 	<ul style="list-style-type: none"> Hazard assessed as being very low risk. Extremely low frequency of detection on the lines (Table 2). Detection occurred and there was significant confirmation of diagnoses by the prospective trial (Table 5) in breeders.
F/B	E	Carcasses	Granulomatous lymphadenitis (<i>Mycobacterium</i> sp.)	NI**	NI**	X	NI**	No	No	<ul style="list-style-type: none"> Maintain evaluation only of mesenteric lymph nodes. When detected in mesenteric lymph nodes - the heads, viscera and carcasses are railed out to the DIF for evaluation of other lymph nodes and suitable disposition. Minimization of exposure of tissues and rupture of lymph tissues. 	<ul style="list-style-type: none"> Low and very low-risk hazards. Uncertainty as to the importance of pork in the human infection chain. Handling and opening head tissues and exposure of the tongue may amplify the higher-risk hazards present in the tissues. Detection mainly of lymphadenitis in cuts of mesenteric lymph nodes (76% in finisher pigs). Loss of sensitivity less than 15%.

NI**= Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain Visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible line procedure recommended	Summary of scientific opinion	Reference of justification
	F/B	E	Carcasses	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Classification is coordinated by the RV. If there is a lesion of viscera comprising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV. Carcasses showing changes in coloring, odor and shape must be railed out to the DEC in accordance with the standard laid down in the carcass and viscera classification program prepared by the RV (in compliance with the legislation). Carcasses identified on the mesentery line must continue accompanied by all viscera and parts to the DIF for the AFFA to assess them. The AFFA may, at his or her discretion, order other carcasses and viscera to be railed out to the DIF. AFFA audit of classification procedures. 	<ul style="list-style-type: none"> Remaining lesions detected on the inspection lines were not indicative of zoonoses or animal-health diseases. AFFAs have reported that the vesicles are not easily identified after scalding: the receiving step and the bleeding table are the most suitable locations for the examination.
			Non-specific lesions and notifiable diseases (syndromes) only identified at PM*								
										<p>Viscera must be classified only if they are to be sold as edible, or if they are intended for making up fresh or processed edible products (when they are not classified, they must all be given the same disposition as condemnation, above all taking into consideration compliance with market requirements in the event of exportation of inedible products).</p>	

*PM = post-mortem examination.

NI** = Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible recommended	Summary of scientific opinion	Reference of justification
F/B	B	Stomachs	Gastrointestinal (zoonotic) microorganisms	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Only classified when the viscera are intended for direct human consumption or to make up products. Classification and treatment of the contaminated part (product) and of the cause of contamination (process) by RV. AFFA audit of classification procedures. Minimize exposure of gastrointestinal contents in the slaughter area. Monitoring program to evaluate process hygiene on carcass. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by contamination of the gastrointestinal contents. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process - and product-related actions.
F/B	B	Stomachs	Granulomatous lymphadenitis (<i>Mycobacterium</i> sp.)	NI**	NI**	NI**	NI**	No	No	<ul style="list-style-type: none"> Responsible veterinarian coordinates classification into fit / not fit for consumption. If there is a lesion of viscera comprising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV. AFFA audit of classification procedures. 	<ul style="list-style-type: none"> Remaining lesions detected on the inspection lines were not indicative of zoonoses of animal-health diseases.

NI** = Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible recommended	Summary of scientific opinion	Reference of justification
F/B	B	Spleens	Gastrointestinal (zoonotic) microorganisms	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> The spleen is only examined when the viscera are intended for direct human consumption or to make up products. Classification and treatment of the contaminated part (product) and of the cause of contamination (process) by RV. AFFA audit of classification procedures. Monitoring program to evaluate process hygiene on carcass. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by contamination of the gastrointestinal contents. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process- and product-related actions.
F/B	B	Spleens	Granulomatous lymphadenitis (<i>Mycobacterium</i> sp.)	NI**	NI**	NI**	NI**	No	No	<ul style="list-style-type: none"> Maintain evaluation only of mesenteric lymph nodes. When detected in mesenteric lymph nodes - the heads, viscera and carcasses are railed out to the DJF for evaluation of other lymph nodes and suitable disposition. Minimization of exposure of tissues and rupture of lymph tissues. 	<ul style="list-style-type: none"> Low and very low risk hazards. Uncertainty as to the importance of pork in the human infection chain. Handling and opening head tissues and exposure of the tongue may amplify the higher-risk hazards present in the tissues. Detection mainly of lymphadenitis in cuts of mesenteric lymph nodes (76% in finisher pigs). Loss of sensitivity less than 15%.

NI** = Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objectives of the inspection procedure	Maintain Visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible procedure recommended	Summary of scientific opinion	Reference of justification
F/B	B	Spleens	Non-specific lesions or those without repercussions for the carcass, and notifiable diseases (syndromes) only identified at PM*	NI**	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Responsible veterinarian coordinates classification into fit / not fit for consumption. If there is a lesion of viscera comprising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV. AFFA audit of classification procedures. 	<ul style="list-style-type: none"> Remaining lesions detected on the inspection lines were not indicative of zoonoses or animal-health diseases. AFFAs have reported that the vesicles are not easily identified after scalding: the receiving step and the bleeding table are the most suitable locations for the examination.
F/B	F	Kidneys	Gastrointestinal (zoonotic) microorganisms	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Examination only performed when the viscera are intended for direct human consumption or to make up products. Classification and treatment of the contaminated part (product) and of the cause of contamination (process) by RV. AFFA audit of classification procedures. Minimization of exposure of tissues and rupture of muscle and lymph Monitoring program to evaluate process hygiene on carcass. 	<ul style="list-style-type: none"> Hazards of high, low and very low risk are carried by contamination of the gastrointestinal contents. Contamination owing to rupture of gastrointestinal tract may amplify several hazards ranging from high to very low risk. It is easier for the establishment to identify the origin of the contamination and take immediate process-related action in order to address the issue. When the establishment does not have control of evisceration hygiene, the AFFA evaluates this and takes process - and product-related actions.

*PM = post-mortem examination.

NI** = Not indicated.

Finisher/ Breeder	Line	Part/viscus	Group of related hazards and objective of the inspection procedure	Maintain visual evaluation	Maintain palpation	Maintain cut	Ask for laboratory confirmation	Official line procedure recommended	Veterinarian responsible recommended	Reference of justification
F/B	F	Kidneys	Non-specific lesions or those without repercussions for the carcass, and notifiable diseases (syndromes) only identified at PM	X	NI**	NI**	NI**	No	Yes	<ul style="list-style-type: none"> Responsible veterinarian coordinates classification into fit / not fit for consumption. If there is a lesion of viscera comprising the carcass, then the carcass and whole set of viscera are railed out to the Supplementary Examination Department (DEC) for examination, diagnosis and treatment (if necessary) by the RV AFFA audit of classification procedures. Remaining lesions detected on the inspection lines were not indicative of zoonoses or animal-health diseases.

*PM = post-mortem examination.

NI** = Not indicated.

Line for the evaluation and classification of heads, jowls and tongues (mandatory)

Description of traditional examination (Ordinance 711/95)

- Visual inspection, by opening the jowl and exposing the tongue.
- Cutting of masseters and pterygoids by means of long deep incisions in order to provide as large a surface as possible for exploration.
- Longitudinal, ventral, incisions of the tongue musculature.
- Longitudinal cut of the parotid lymph nodes and parotid glands.
- Cutting the cervical, retropharyngeal and mandibular lymph nodes and salivary glands.
- Palpation of the tongue.

Procedures proposed for risk-based inspection

a) Objectives:

- To mitigate the extent of hazards that are potentially present in the oropharynx and cervical lymph nodes (salmonella among others).
- To identify failures in evisceration (visible contamination) and take process-related corrective actions.
- To ensure that products not meeting the expected characteristics and quality cannot be consumed.

b) Preparatory phase:

- Examine the head, jowl and tongue set on the inspection line along with the lower part of the carcass, or separately, provided that the correlation and the hygiene of the process are maintained.
- Reduce, as far as possible, the exposure of lymph tissues and restrict incisions into the musculature when handling the head. The incision must always be made caudally to the jowl, dorso-ventrally, without opening into the oral cavity, thus minimizing the incisions and the exposure of ad-

jacent lymphatic and glandular tissues, or of muscle masses, and without exposing the tongue.

- Minimize points of contact and cross-contamination from slaughter structures and equipment.
- Submit the head, tongue and adjacent tissues to treatments in order to mitigate bacterial hazards present in the head-tongue set (physical removal of lymph nodes followed by heat treatment or another compensatory treatment, above all when intended to be raw material for fresh sausage products, provided that this is authorized by Dipoa).

c) Visual evaluation by classifier on the slaughter line:

- Visual examination must take place after evisceration.
- Using a hook, inspect the external surfaces of the head-jowl set (with tongue).
- Only expose and incise the oral cavity or lymph nodes and glands at supplementary veterinary examination in the DEC or DIF, in accordance with findings in other organs.

d) Classification:

- Keep on the line any head, jowl, tongue set on which no abnormalities have been found that could either make it unfit for consumption or spread contamination to downstream processes.
- Classify any contaminated head, jowl, tongue set, bearing abscesses or non-specific lesions that themselves do not result from, or cause, changes to the carcass, as inedible.
- Remove minor lesions and contamination on the lines.

e) Classification of the findings:

- Lesions not causing carcass changes.
- Contamination.
- Rail out to DEC.

Table 12. Legal provision for the more frequent detections in the head-jowl (and tongue) set.

Lesions	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Contamination	Condemnation		Carcasses, carcass parts and organs showing an extensive area of contamination by gastrointestinal contents, urine, milk, bile, pus or any other type of contamination, must be condemned when it is impossible to completely remove the contaminated area.	147
Abscesses/purulent processes	Rail out to DEC	See Table 18	Carcasses, carcass parts and organs presenting with multiple or widespread abscesses that affect the overall status of the carcass must be condemned - further observe: items I to V.	134
Lesions without repercussions for the carcass	Condemnation		Carcasses, carcass parts and organs showing lesions or abnormalities that do not affect the carcass or other organs, may be condemned or alternatively authorized to continue on the inspection lines, pursuant to supplementary norms.	128
Traumatic lesion	Condemnation		Carcasses presenting localized contusions, fractures or dislocations may be authorized once the affected areas have been removed and condemned.	148

Line for the evaluation and classification of hearts (mandatory)

Description of traditional examination (Ordinance 711/95)

- Visual examination of heart and pericardium. Incision of the pericardial sac.
- Visual examination of the epicardium, surface of the heart, under warm running water at 38 to 40°C (thirty-eight to forty degrees centigrade).
- Palpation of the organ.
- Longitudinal incision under warm shower (38 to 40°C: thirty-eight to forty degrees centigrade) of left heart, at the base of the apex, prolonging the incision through the interventricular wall into the right heart, thus exposing a greater atrioventricular area.
- Visual examination of endocardium and valves.

Procedures proposed for risk-based inspection

a) Objectives:

- To identify failures in the process and reduce the amplification of hazards potentially present in the gastrointestinal contents (salmonella species, among others).
- To eliminate incisions into the musculature for investigating zoonotic parasitoses that have been proven to have a very low or negligible risk in finisher swine coming from farms where there is biosecurity.
- To identify inflammatory lesions of vegetative endocarditis compatible with *Streptococcus suis* and *Erysipelothrix rhusiopathiae*.
- Make sure that products not meeting the expected characteristics and quality cannot be consumed and sold.

b) Preparatory phase:

- Remove the viscera from the carcass and remove the heart-pericardium set from the thoracic viscera.
- Maintain correlation with the carcass until the completion of the assessments of all remaining viscera and carcass parts.
- Minimize points of contact and cross-contamination from slaughter structures and equipment.

c) Visual evaluation by classifier on the slaughter line:

- Remove the pericardium in order to observe the external surface of the heart.
- Observe the inner surface of the heart; incise and expose the valves to check for inflammatory lesions.

d) Classification:

- Keep all hearts deemed fit for consumption or processing on the line.
- Classify any contaminated heart, with inflammatory or non-specific lesions that themselves do not result from, or cause, changes to the carcass, as inedible.

e) Classification of the findings:

- Lesions not causing carcass changes.
- Contamination.
- Rail out to DEC.

Tabela 13. Previsão legal para as detecções mais frequentes no coração.

Lesions	Classification	Decree nº 9,013 enacted March 29, 2017 (Riispoa) amended by Decree nº 9,069 enacted May 31, 2017	Article
Heart lesion without repercussions for the carcass	Condemnation	Carcasses, carcass parts and organs showing lesions or abnormalities that do not affect the carcass or other organs, may be condemned or alternatively authorized to continue on the inspection lines, pursuant to supplementary norms.	128
Contamination	Condemnation	Carcasses, carcass parts and organs showing an extensive area of contamination by gastrointestinal contents, urine, milk, bile, pus or any other type of contamination, must be condemned when it is impossible to completely remove the contaminated area.	147
Heart lesion without repercussions for the carcass	Condemnation	Hearts with lesions of myocarditis, endocarditis and pericarditis may be condemned.	158

Line for the evaluation of intestines, stomachs, spleens, pancreas and bladders

Description of traditional examination (Ordinance 711/95)

- Visual examination; palpating and incising (when necessary) the set comprising stomach, intestines, pancreas, spleen and bladder.
- Incising stomach lymph nodes.
- Slicing lymph nodes of the mesenteric chain.
- External visual examination and palpation (appearance, volume, coloring and consistency) of the spleen.
- Incising stomach lymph nodes.

Procedures proposed for risk-based inspection

Federal Inspection Service (SIF) mesenteric lymph node inspection line (mandatory)

a) Objectives:

- To identify inflammatory lesions of the lymph network in order to prepare the supplementary examination by the AFFA: if granulomatous lymphadenitis is diagnosed, (s)he will determine the degree of infection of the carcass and the correct procedure to mitigate the hazards associated with the lesion (mycobacteriosis).

b) Preparatory phase (company):

- Remove the set of green offals from the carcass, preventing them from touching the red offals.
- Position the intestines so as to facilitate the cutting of the mesenteric lymph nodes by the Federal Inspection Service (SIF) employee.
- Maintain correlation with the carcass until the completion of the assessments of all remaining viscera and carcass parts.
- Minimize points of contact and cross-contamination from slaughter structures and equipment.

c) Official service inspection of the intestine:

- Incise the lymph nodes of the mesenteric chain seeking to identify granulomatous lymphadenitis lesions.
- Identify any inflammatory lesions that have been detected and order the viscera and carcass to be railed out to the DIF for the AFFA to examine.

d) Post-Mortem inspection by AFFA:

Carcasses, viscera and heads arriving in the DIF for examination by the AFFA will undergo all necessary examinations to identify the scope and spread of a hazard in the carcass, and dispositions will be given in accordance with the Inspection Regulation. Ordinance 711 has defined the minimum procedures. Any carcasses arriving for inspection without parts or viscera will be totally condemned.

Proposed procedures for the risk-based evaluation and classification of green offals**a) Objectives:**

- To identify the origin of the contamination by gastrointestinal content, and to take offsetting actions at product level, and corrective actions at process level (origin of the contamination).
- To make sure that products not meeting the expected characteristics and quality cannot be consumed.

b) Preparatory phase:

- Remove the set of green offals from the carcass, preventing them from touching the red offals.
- Position the intestines so as to facilitate the cutting of the mesenteric lymph nodes by the Federal Inspection Service (SIF) employee.
- Maintain correlation with the carcass until the completion of the assessments of all remaining viscera and carcass parts.
- Minimize points of contact and cross-contamination from slaughter structures and equipment.
- If the uterus, stomach, spleen, bladder and pancreas are intended for sale for human consumption, they must undergo the assessment provided for in “c” and the classification provided for in “d”.

c) Visual evaluation by classifier on the slaughter line:

- Visually examine the external part of the set of green offals.
- Only incise when necessary, so as to avoid leakage of contaminating contents. Prioritize palpation in order to assess whether the volume has increased or the shape changed.

d) Classification:

- Keep any set of green offals deemed fit for consumption on the line.
- Any set of viscera contaminated with feces or infested with parasites, or bearing non-specific lesions that have not resulted from, or caused, changes in the carcass, is to be deemed edible.

e) Classification of the findings:

- Lesions not causing carcass changes.
- Contamination.
- Rail out to DEC.

Table 14. Legal provision for the most frequent findings in the white offals.

Lesions	Classification	Decree no. 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Contamination	Condemnation	Carcasses, carcass parts and organs showing an extensive area of contamination by gastrointestinal contents, urine, milk, bile, pus or any other type of contamination, must be condemned when it is impossible to completely remove the contaminated area.	147

Lesions	Classification	Decree no. 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Lesion of green viscera without repercussions for the carcass	Condemnation	Carcasses, carcass parts and organs showing lesions or abnormalities that do not affect the carcass or other organs, may be condemned or alternatively authorized to continue on the inspection lines, pursuant to supplementary norms.	128
Lesion of green viscera without repercussions for the carcass	Condemnation	Organs and parts showing signs of parasitosis that are not transmitted to humans must be condemned, while the carcass may be passed for consumption, provided it has not been affected.	166

Line for evaluation and classification of livers (mandatory)

Description of traditional examination (Ordinance 711/95)

- Visual examination of the surfaces of the organ.
- Palpation of the organ.
- Transversal incision and compression of the bile ducts.
- Cut into longitudinal slices (without dicing) the lymph nodes of the viscera.
- Visual examination and palpation of the gallbladder, incising it if necessary: in a dedicated location, separately.

Procedures proposed for risk-based inspection

a) Objective:

- Identify failures in the process and reduce the amplification of hazards potentially present in the gastrointestinal contents (salmonella species, among others).
- To make sure that products not meeting the expected characteristics and quality cannot be consumed.

b) Preparatory phase:

- Remove the viscera from the carcass and separate the liver from the remaining viscera.
- Maintain correlation with the carcass until the completion of the assessments of all remaining viscera and carcass parts.
- Minimize points of contact and cross-contamination from slaughter structures and equipment.

c) Visual evaluation by classifier on the slaughter line:

- Visually examine the external surface of the livers (both sides).
- Incise only if necessary.

d) Classification:

- Keep all livers deemed fit for consumption or processing on the line.
- Classify any contaminated livers, with inflammatory or non-specific lesions that themselves do not result from, or cause, changes to the carcass, as inedible.

e) Classification of the findings:

- Lesions not causing carcass changes.
- Contamination.
- Rail out to DEC.
- Remove the viscera from the carcass and separate the liver from the remaining viscera.
- Maintain correlation with the carcass until the completion of the assessments of all remaining viscera and carcass parts.
- Minimize points of contact and cross-contamination from slaughter structures and equipment.

Table 15. Legal provision for the most frequent findings in the liver.

Lesion/ Registration	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Abscesses/purulent processes	Rail out to DEC	See Table 18	Carcasses, carcass parts and organs presenting with multiple or widespread abscesses that affect the overall status of the carcass must be condemned - further observe: items I to V.	134
Liver lesion without repercussion for the carcass	Condemnation		Livers with atrophic or hypertrophic cirrhosis must be condemned.	145
Liver lesion with repercussions for the carcass	Condemnation		Carcasses, carcass parts and organs with a repugnant appearance, showing congestion, abnormally colored or with degeneration must be condemned.	143
Contamination	Condemnation		Carcasses, carcass parts and organs showing an extensive area of contamination by gastrointestinal contents, urine, milk, bile, pus or any other type of contamination, must be condemned when it is impossible to completely remove the contaminated area.	147
Liver lesion without repercussion for the carcass	Condemnation		Carcasses, carcass parts and organs showing lesions or abnormalities that do not affect the carcass or other organs, may be condemned or alternatively authorized to continue on the inspection lines, pursuant to supplementary norms.	128
Liver lesion without repercussion for the carcass	Condemnation		Organs and parts showing signs of parasitosis that are not transmitted to humans must be condemned, while the carcass may be passed for consumption, provided it has not been affected.	166

Line for the evaluation and classification of lungs (mandatory)

Description of traditional examination (Ordinance 711/95)

- Visual examination of the surface of the lungs, trachea and esophagus.
- Palpate.
- Without dicing, slice the apical, bronchial and esophageal lymph nodes.
- Incision into the lungs at the level of the bronchi and bronchioles to enable exploration of the bronchial lumen, which is performed in order to check the state of the mucosae.
- Cutting of the parenchyma when necessary.

Procedures proposed for risk-based inspection

a) Objective:

- To identify failures in the process and reduce the amplification of hazards potentially present in the gastrointestinal contents (salmonella species, among others).
- To identify animals that may still have been breathing when scalded (aspiration of scalding water) in order to take process-related actions.
- To rule out the possibility of the consumption of products that fail to meet the expected characteristics and quality: if lungs, the disposition is to go to make edible products or to go to animal feed.

b) Preparatory phase:

- Remove the thoracic viscera from the carcass, taking care regarding possible adherences and abscesses which may contaminate the process.
- Maintain correlation with the carcass until the completion of the assessments of all remaining viscera and carcass parts.

- Minimize points of contact and cross-contamination from slaughter structures and equipment.

c) Visual evaluation by classifier on the slaughter line:

- Observe the outer surface of the lung.
- Palpate to identify changes in texture and nature of lesions.

d) Classification:

- Lungs deemed fit for consumption or processing, not bearing visible or palpable lesions of the parenchyma or lymph tissue, are to be kept on the line.
- Classify any contaminated lungs, with aspiration of extraneous content, or inflammatory or non-specific lesions that themselves do not result from, or cause, changes to the carcass, as inedible.

e) Classification of the findings:

- Lesions not causing carcass changes.
- Contamination.
- Aspiration of water.
- Rail out to DEC.

f) Remarks:

- Carcasses that have been railed out to DIF or DEC will be classified as inedible when the abdominal viscera are present.
- Carcasses with adherences of thoracic viscera, or those carcasses that have been examined on the official inspection lines, may undergo a supplementary examination in the DEC and receive a disposition in accordance with the findings.

Table 16. Legal provision for the most frequent findings in the lung.

Lesion/ Registration	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Abscesses/purulent processes	Rail out to DEC	See Table 18	Carcasses, carcass parts and organs presenting with multiple or widespread abscesses that affect the overall status of the carcass must be condemned - further observe: items I to V.	134
Contamination	Condemnation		Carcasses, carcass parts and organs showing an extensive area of contamination by gastrointestinal contents, urine, milk, bile, pus or any other type of contamination, must be condemned when it is impossible to completely remove the contaminated area.	147
Aspiration of liquid (welfare)	Condemnation		All suidae that have died of asphyxiation, whatever the cause, and those that have been scalded alive, must be condemned.	203
Lung lesion without repercussions for the carcass	Condemnation		Lungs presenting inflammatory, infectious, parasitic, or traumatic lesions or lesions from the dying process, must be condemned, but without prejudice to the examination of the general characteristics of the carcass.	136
Lung lesion without repercussions for the carcass	Condemnation		Carcasses, carcass parts and organs with a repugnant appearance, showing congestion, abnormally colored or with degeneration must be condemned.	143

Kidney evaluation and classification line (optional – when they are intended for making up products for human consumption)

Description of traditional examination (Ordinance 711/95)

- Removal of kidneys from the carcass, visual examination of kidneys, palpation and judgment of coloring, appearance, volume and consistency.
- Incision, when necessary, into the perirenal fat.
- Cutting the parenchyma, if necessary, to examine the state of the cortical and medullary layers.

Procedures proposed for risk-based inspection

a) Objectives:

- To identify failures in the process and reduce the amplification of hazards potentially present in the gastrointestinal contents (salmonella species, among others).
- To make sure that products not meeting the expected characteristics and quality cannot be consumed.

b) Preparatory phase:

- Remove the kidneys from the carcass.
- If the kidneys are intended for sale for human consumption, or if they need to comply with certification requirements for inedible by-products, they must undergo the evaluation provided for in “c” and the classification provided for in “d”.

c) Classifier performs visual examination on the slaughter line (when the kidneys are used for edible purposes):

- Remove the kidneys from the carcass and the renal capsule and classify them.
- Maintain correlation with the carcass until the completion of the assessments of all remaining viscera and carcass parts.
- Minimize points of contact and cross-contamination from slaughter structures and equipment.

d) Classification:

- Keep all kidneys deemed fit for consumption or processing on the line.
- Classify any contaminated kidneys, with inflammatory lesions, cysts or non-specific lesions that themselves do not result from, or cause, changes to the carcass, as inedible.

e) Classification of the findings:

- Lesions not causing carcass changes.
- Contamination.
- Rail out to DEC.

Table 17. Legal provision for the most frequent findings in the kidneys.

Lesion/ Record	Classification	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Contamination	Condemnation	Carcasses, carcass parts and organs showing an extensive area of contamination by gastrointestinal contents, urine, milk, bile, pus or any other type of contamination, must be condemned when it is impossible to completely remove the contaminated area.	147
Kidney lesion without reper- cussion for the carcass	Condemnation	Kidneys showing signs of nephritis, nephrosis, pyelonephritis, uronephrosis, urinary cysts or other infections must be condemned, and the lesions must be investigated for a possible link to infectious or contagious or parasitic diseases and whether they lead to changes in the carcass.	159

Line for the evaluation and classification of carcasses

Description of traditional examination (Ordinance 711/95)

- Visual examination of the internal and external surfaces of carcasses, checking them for appearance, coloring, nutritional status, skin, abdominal and thoracic serosae, and exposed bone surfaces.
- Check whether there are abnormalities in the joints and muscle masses, with any necessary incisions.
- Examine whether there are any locally-restricted or disseminated gastrointestinal or bile contaminations, contusions, abscesses, hemorrhages, or edemas.
- Observe whether there is muscle rigidity.
- By skinning with a knife, examine the upper inguinal (or supramammary) lymph nodes, and the anterior and posterior iliac lymph node, taking care neither to remove them nor to displace them.
- When necessary examine the mammary glands, making deep incisions.

- In the case of spent breeders, the diaphragm must be investigated for cysticercosis, even if this particular parasitosis has not been detected on the other inspection lines.

Procedures proposed for risk-based inspection

a) Objectives:

- To identify failures in the process and reduce the amplification of hazards potentially present in the gastrointestinal contents (salmonella species, among others).
- To identify minor changes that can be removed on the line, such as dry adherences and small contusions.
- To identify, and send for examination by the RV, those carcasses that do not meet the expected characteristics and quality (changes in color, odor, shape and so on) along with the matching heads and viscera, in accordance with necessities defined in the regulation.

b) Preparatory phase:

- Evisceration and longitudinal cut in carcasses.
- Carcasses and half-carcasses must remain correlated to each other and to their other parts and viscera.
- Minimize points of contact and cross-contamination from slaughter structures and equipment.
- Carcasses to which viscera and abdominal viscera adhere must not be split longitudinally on the line, but are compulsorily to be railed to DEC.

c) Visual evaluation by classifier on the slaughter line:

- Using a hook, turn the half-carcasses for visual assessment of their internal and external surfaces (when the head is still attached to the carcass, it may be examined at the same point as the carcass).

- When appropriate, the head and jowl set may be examined on the carcass line in accordance with procedures laid down in the item addressing “Parasitic disease-related hazards”.
- Send for veterinary examination (RV) any carcasses showing changes in color, odor or shape, and notify other lines that the other viscera and carcass parts are also to be sent.

d) Classification:

- Keep only those carcasses deemed fit for consumption on the line or in processing.
- Using a hook and knife, remove small lesions and contamination and any viscera adhering to the carcass (dry visceral and parietal pleuritis and adhering parietal peritonitis).
- If carcasses show any changes, they are to be railed out for veterinary examination by the VR along with their viscera, other carcass parts, and the head - jowl - tongue set.
- The self-control plan may define the circumstances in which viscera and carcass parts are exempt from being submitted for such examination, with justification based on mandatory examinations, by cause of disqualification.
- When the extent of the defects caused by a processing failure does not allow removal of the affected parts on the slaughter line, the carcasses are to go to veterinary examination by the RV, and it is not necessary for the viscera to accompany them.

e) Classification of the findings:

- Lesions not causing carcass changes.
- Contamination.
- Rail out to DEC.

Table 18. Legal provision for the most frequent findings in carcasses.

Arthritis		with		repercussions	
Lesion/ Registration	Description	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Delayed evisceration	Delayed evisceration, and non-eviscerated carcasses (presence of abdominal or thoracic viscera)	Rail out to DEC	RV validates dispositions and treatments	If evisceration is delayed, the carcass and viscera will be judged according to supplementary norms.	118
Hernia without repercussions for the carcass	Localized hernia (hernias with dry chronic peritonitis localized in the hernial sac and contiguous abdominal wall)	Removal of the affected part	RV validates dispositions and treatments	Carcasses, carcass parts and organs showing lesions or abnormalities that do not affect the carcass or other organs, may be condemned or alternatively authorized to continue on the inspection lines, pursuant to supplementary norms.	128
Cannibalism/tail biting without repercussion for the carcass	Lesion from localized cannibalism/tail biting (without inflammation)	Removal of the affected part	RV validates dispositions and treatments	Carcasses, carcass parts and organs showing lesions or abnormalities that do not affect the carcass or other organs, may be condemned or alternatively authorized to continue on the inspection lines, pursuant to supplementary norms.	128
Abscesses/purulent processes	Abscesses and suppurating lesions (resulting from trauma, cannibalism/tail biting, exacerbation of hernias, etc.)	Affected part removed or railed out to DEC	Removal of the affected part	Carcasses presenting with localized abscesses may be approved for further processing after the organs and areas affected have been removed and condemned.	134
Multiple abscesses/purulent processes	Abscesses and suppurating lesions (trauma, cannibalism/tail biting, exacerbation of hernias, etc.)	Rail out to DEC	Total condemnation	Carcasses, carcass parts and organs presenting with multiple or widespread abscesses with repercussions for the overall status of the carcass must be condemned.	134

Lesion/ Registration	Description	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Abscesses/ purulent processes	Abscesses and suppurating lesions (trauma, cannibal- ism/tail biting, exacerbation of hernias, etc.)	Rail out to DEC	Heat treatment (validated treatments)	Carcasses presenting multiple abscesses in organs or carcass parts, not affecting the overall state, are to be sent for conditional heat treatment after the affected areas have been removed and condemned.	134
Pleural adherences (resolved pleuritis)	Pleural adhesions (dry pleura)	Affected part re- moved or railed out to DEC	Removal of the affected part	In those cases where there is pleural adhesion without any kind of exudate, that are the result of resolved pa- thological processes and without any repercussions for the regional lymphatic chain, the carcass may be au- thorized for consumption after the affected areas have been removed.	136
Lung lesion with repercus- sions for the carcass	Pleural adhesions/ pneumonia	Rail out to DEC	Total condemnation	The carcasses of animals affected by extensive lung tissue diseases, in either acute or chronic, purulent, necrotic, gangrenous, fibrinous condition, or associated (or otherwise) with other complications, and affecting the overall condition of the carcass, must be condem- ned.	136
Lung lesion with repercus- sions for the carcass	Pleural adhesions/ pneumonia	Rail out to DEC	Heat treatment (validated treatments)	The carcasses of animals affected by lung diseases, either in an acute process or in a resolution phase, ha- ving involved lung tissue and pleura, with exudate and affecting the regional lymphatic chain, but without affect- ing the overall condition of the carcass, must be sent to conditional use after heat treatment.	136
Acute peritonitis	Peritonitis	Rail out to DEC	Total condemnation	The carcasses of animals with septicemia, pyemia, toxemia or signs of viremia, and whose consumption might cause infection or food poisoning, must be con- demned I - Acute inflammation of the pleura, the perito- neum, pericardium and meninges.	137

Lesion/ Registration	Description	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Cachexia	Cachexia	Rail out to DEC	Total condemnation	Carcasses and organs of cachectic animals must be condemned.	139
Anemia/pallor	Anemia	Rail out to DEC	Total condemnation	Carcasses must be condemned if their meat is flaccid, bruised, pale, bloody or exudative.	142
Changes due to stress/fatigue	Rigor mortis/cadaveric spasm	Rail out to DEC	Validated technological treatment	Carcasses with changes owing to stress or fatigue in the animals may, at the discretion of the SIF, be sent for salting, heat treatment, or condemnation.	142
Failure at scalding/dehairing/singeing/splitting	Failures in the slaughter process (that do not cause delay in evisceration)	Rail out to DEC	Removal of the affected part	Carcasses, carcass parts and organs with a repugnant appearance, showing congestion, abnormally colored or with degeneration must be condemned.	143
Failure at scalding/dehairing/singeing/splitting	Failures in the slaughter process not however causing delay in evisceration	Rail out to DEC	Total condemnation	Carcasses, carcass parts and organs with a repugnant appearance, showing congestion, abnormally colored or with degeneration must be condemned.	143
Incomplete bleeding	Incomplete bleeding	Rail out to DEC	Heat treatment (validated treatments)	Carcasses and organs of improperly bled animals must, at the discretion of the SIF, be sent for heat treatment.	144
Incomplete bleeding	Incomplete bleeding	Rail out to DEC	Total condemnation	Carcasses and organs of improperly bled animals must, at the discretion of the SIF, be sent for heat treatment.	144
Liver lesion with repercussions for the carcass	Cirrhosis	Rail out to DEC	Total condemnation, or condemnation of the affected part	Livers with atrophic or hypertrophic cirrhosis must be condemned. Sole paragraph. Carcasses similar to the description in the head provision, provided they are not affected, may be approved for use.	145

Lesion/ Registration	Description	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Contamination	Removable contamination	Affected part removed or railed out to DEC	Removal of the affected part	Carcasses, carcass parts and organs showing an extensive area of contamination by gastrointestinal contents, urine, milk, bile, pus or any other type of contamination, must be condemned when it is impossible to completely remove the contaminated area.	147
Contamination	Non-removable contamination	Rail out to DEC	Total condemnation	Carcasses, carcass parts and organs showing an extensive area of contamination by gastrointestinal contents, urine, milk, bile, pus or any other type of contamination, must be condemned when it is impossible to completely remove the contaminated area.	147
Contamination	Diffuse contamination on the carcass	Rail out to DEC	Heat treatment (validated treatments)	When it may be impossible perfectly to delimit the contaminated areas, even after removal, then the carcasses, carcass parts, organs or viscera must be sterilized by heat.	147
Traumatic lesion	Contusions/fractures/hematomas	Affected part removed or railed out to DEC	Removal of the affected part	Carcasses presenting localized contusions, fractures or dislocations may be authorized once the affected areas have been removed and condemned.	148
Traumatic lesion	Contusions/fractures	Rail out to DEC	Total condemnation	Carcasses of animals with widespread contusions or multiple fractures must be condemned.	148
Traumatic lesion	Contusions/fractures	Rail out to DEC	Heat treatment (validated treatments)	Carcasses with widespread lesions that have not been totally compromised are to go to heat treatment after the affected areas have been removed and condemned.	148
Jaundice	Jaundice	Rail out to DEC	Total condemnation	Carcasses and organs of animals presenting jaundice must be condemned.	156

Lesion/ Registration	Description	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Cardiac lesion with reperussions for the carcass	Traumatic endocarditis/pericarditis	Rail out to DEC	Total condemnation	The carcasses of animals with cardiac lesions may be condemned or sent to heat treatment whenever this affects the overall condition, at the discretion of the SIF.	158
Cardiac lesion with reperussions for the carcass	Traumatic endocarditis/pericarditis	Rail out to DEC	Heat treatment (validated treatments)	The carcasses of animals with cardiac lesions may be condemned or sent to heat treatment whenever this affects the overall condition, at the discretion of the SIF.	158
Lymphadenitis	Non-specific lymphadenitis	Rail out to DEC	Total condemnation	Carcasses showing non-specific widespread lesions in the lymph nodes of several regions, affecting the overall state of the carcass, must be condemned.	160
Neoplasia	Neoplasia	Rail out to DEC	Removal of the affected part	In the case of discrete localized neoplastic lesions that do not affect the overall state, the carcass may be authorized for consumption after the affected parts and organs have been removed and condemned.	165
Neoplasia	Neoplasia	Rail out to DEC	Total condemnation	Carcasses of animals with extensive neoplasms that have repercussions for the overall state, must be condemned.	165
Neoplasia	Neoplasia	Rail out to DEC	Heat sterilization (validated)	In the event of extensive neoplastic lesions that are localized and do not affect the overall state, then the carcass and organs may be sent to heat sterilization and the involved parts and organs must be removed and condemned.	165
Skin lesions	Dermatitis/skin lesion	Remove on the line or rail out to DEC	Removal of the affected part	Carcasses presenting skin conditions such as erythema, sclerodermy, urticaria, cystic hypotrichosis, mange and other types of dermatitis, may be approved for consumption after the affected areas have been removed, provided that the musculature is normal.	195

Lesion/ Registration	Description	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Skin lesions	Mange	Rail out to DEC	Total condemnation	Carcasses affected by advanced-stage mange, showing signs of cachexia or extensive muscle inflammation, are to be condemned.	195
Arthritis	Arthritis	Rail out to DEC	Removal of the affected part	Carcasses with arthritis but without a reaction in the lymph nodes or repercussions for their overall status may be approved for consumption after the affected part has been removed.	196
Arthritis with repercussions for the carcass	Arthritis	Rail out to DEC	Total condemnation	Carcasses with arthritis in one or more joints, with a lymph node reaction or hypertrophy of the synovial membrane, accompanied by cachexia, are to be condemned.	196
Arthritis with repercussions for the carcass	Arthritis	Rail out to DEC	Heat treatment (validated treatments)	Carcasses with arthritis in one or more joints, with a lymph node reaction and hypertrophy of the synovial membrane, without repercussions for the overall status: disposition is to be partial use after heat treatment.	196
Failures in castration	Boar taint	Rail out to DEC	Total condemnation	Carcasses of animals with cryptorchidism or that have been castrated by non-surgical methods, when a strong boar taint is found by means of the specific tests laid down in the supplementary standard, are to be condemned.	198
Failures in castration	Boar taint	Rail out to DEC	Validated technological treatment	Carcasses with a milder form of boar taint may go to the manufacture of cooked pork products.	198
Erysipelas	Multiple skin lesions and arthritis exacerbated by necrosis, or systemic signs	Rail out to DEC	Total condemnation	Carcasses of suidae with erysipelas and presenting multiple skin lesions, arthritis aggravated by necrosis, or when there are signs of a systemic effect, are to be condemned.	199

Lesion/ Registration	Description	Classification	DEC	Decree n° 9,013 enacted March 29, 2017 (Riispoa) amended by Decree n° 9,069 enacted May 31, 2017	Article
Chronic arthritis with skin lesions of erysipelas or vegetative endocarditis	Erysipelas	Rail out to DEC	Heat treatment (treatments validated for Erysipelas)	In cases of localized erysipelas-related vegetative endocarditis where there are no systemic changes, or in cases of chronic arthritis, the carcass will go to heat-treatment for conditional use, after the organ or affected organs have been condemned.	199
Erysipelas	Skin lesions without systemic repercussions	Rail out to DEC	Remove the affected part	When a skin lesion is discrete and localized, and there is no involvement of the organ or carcass: disposition of the carcass is conditional use after heat treatment, after the affected area has been removed.	199
Endocardite vegetativa	Erysipelas	Rail out to DEC	Heat treatment (treatments validated for Erysipelas)	In cases of localized erysipelas-related vegetative endocarditis where there are no systemic changes, or in cases of chronic arthritis, the carcass will go to heat-treatment for conditional use, after the organ or affected organs have been condemned.	199
Linfadenites inespecificas	Lymphadenitis of organs or carcasses detected on sorting lines (organs and carcasses)	Rail out to DEC	Total condemnation or rail to DIF	In cases of localized erysipelas-related vegetative endocarditis where there are no systemic changes, or in cases of chronic arthritis, the carcass will go to heat-treatment for conditional use, after the organ or affected organs have been condemned.	160

Supplementary duties of the responsible veterinarian

- To prepare, for use on the lines, a classification plan to comply with the provisions of regulations and present standards for the evaluation and disposition in situations not provided for (e.g., tail biting, hernias) based on hazard analysis.

Supplementary duties of Federal Agricultural Inspectors/ Auditors (AFFAs) who have graduated in veterinary medicine with regard to the post-mortem examination

- To examine carcasses and viscera that have been railed to the DIF.
- To perform the minimum procedures as laid down in Ordinance 711/95; these may be extended by confirmatory laboratory tests whenever deemed relevant.
- To record and give a disposition to carcasses that come into the DIF with missing parts or viscera.

Auditing by the AFFA of self-control procedures in the slaughter of swine

Overall objective: To assess the accuracy of pre-slaughter classification and sanitary quality of the slaughter process by sampling carcasses and checking the self-control procedures.

Auditing procedures to isolate animals at ante-mortem and the slaughter process

a) Objectives:

- To identify any deficiencies in the classification of live animals in the lairage sties; animals that could contaminate the slaughter process are to be slaughtered separately.

- To check data from the carcass audit against the evaluation and classification data from the audit of the “Plan for the evaluation and classification of animals, carcasses, carcass parts and viscera”.

b) Procedure:

- Visually examine at least 60 carcasses after slaughter and prior to evisceration.

c) Minimum sample:

- 300 carcasses/week.

d) Records:

- Findings of the evaluation by carcass on dedicated traceable forms (at least by the serial numerical identification of the carcass at slaughter).
- Enforcement actions, when appropriate.

The auditing of evaluation and classification procedures

a) Objective:

- To assess whether classifiers, under instructions from the VR, are complying with regulatory and legal parameters defining the minimum procedures for the evaluation and classification of carcasses and viscera as fit for consumption, or the segregation and treatment of products that are unfit for consumption.

b) Classification lines:

- **Sampling:** evaluate 300 procedures per week (meaning at least 60 observations per inspection and classification line).

- **Procedimento:** Procedure: evaluate operations, encompassing:
 - Preparatory phases and correlation.
 - Evaluation.
 - Classification, including railing to the DEC for examination by the RV.
 - Record-keeping.
- **Record-keeping of the audit:** identification on a dedicated form of failures in:
 - The preparatory phase, hindering evaluation and correlation.
 - The specific procedure laid down for evaluations (palpation/ cutting/ visualization).
 - Identifying changes.
 - Classifying into fit and unfit.
 - Recording on the abacus.
- Identify the deficiencies on a dedicated form and take the enforcement actions (provisional remedy) applicable to a suspected or proven case of the authorization for use of products not fit, or not suitable treated, for consumption.

Auditing the supplementary veterinary examinations performed by the RV

a) Objective:

- To assess whether the VR is maintaining control of operations in the DEC and whether the classifications of products as fit and unfit, or subject to treatment prior to consumption, are being carried out in accordance with the legislation and with the sanitary precepts of consumer protection.
- Examination and classification by the RV.
- Records of classification of products from slaughter by the RV.
- The compliance with standards and, if non-compliant, the technical and scientific compliance of treatments mandated to address deviations.
- Process-related actions taken by the RV.

b) Sampling:

- Random, weekly.

c) Records:

- Identify the deficiencies on a dedicated form and take the enforcement actions (provisional remedy) applicable to a suspected or proven case of the authorization for use of products that are not fit, or that have not been suitably treated, for consumption.

Verification of traceability and application of the treatments determined by the self-control in accordance with the legislation**a) Objective:**

- To assess whether the company adopts the treatments ordered by its technically-responsible individual or by the AFFA in the DIF.

b) Procedure:

- Referring to the individual Record of Evaluation and the carcass classification generated by the RV, verify the segregation of the carcasses in the chillers, and the segregation and suitable identification of the by-products in deboning.
- Product and process-related enforcement actions may be taken at all post-slaughter evaluation steps (carcass and viscera handling and cutting rooms) for any products passed as fit that indicate failures in classification.
- Sampling is to be the evaluation of all carcasses from one slaughtering day, selected at random from a population which is the total number of animals slaughtered in the week. Verification of lots slaughtered on a Friday, or on the days preceding a public holiday, may take place the following week.

Validation in slaughterhouses

The proposal for risk-based inspection was extensively discussed with experienced AFFAs and personnel from the Department of Inspection of Animal Products (Dipoa), and was presented in domestic and international scientific forums (Safepork 2017 and Enepi 2018), which is documented in case file SEI 03402.000001/2018-57. After the initial proposal was drafted the set of measures was validated by pilot projects that were authorized in accordance with Memorandum nº 6/2018/DIPOA/MAPA/SDA/MAPA.

The pilot projects not only enabled observation of the difficulties and benefits in the changes to procedures, from the points of view both of the Federal Inspection Service (SIF) and of the pork producing industry, but they simultaneously helped to gather information in order to evaluate the economic impact. The six plants were chosen as a result of technical pre-requisites; the Federal Agricultural Inspectors/Auditors (AFFAs) who performed the pilot testing were given prior capacity-building. The establishments may be described as follows: 4 of them slaughter swine raised in an integrated production system (SIF 1, 2146, 3681 and 716); 1 slaughters swine from a cooperative system (SIF 2183) and 1 purchases animals from independent farms (SIF 3007). These establishments are located in the states of Rio Grande do Sul (1), Santa Catarina (3), Paraná (1) and Minas Gerais (1).

The duration of the period of performance of each pilot study was three weeks: in the third and final week, Dipoa, project leaders and guests were invited to observe them. The procedures were observed in performance, the results were discussed and compared against data produced earlier in the pilot, the data-gathering forms were tested, and the AFFA responsible for the following pilot study was trained. The procedures carried out on the lines, and the minutes of each pilot study are contained and organized in SEI case file nº 03.402.000005/2018-35.

Validation of the ante-mortem inspection

Comparative evaluation of the sensitivity of ante-mortem examinations performed a) in accordance with the traditional methodology, and b) the proposed risk-based methodology

The ante-mortem inspection proposed by Ordinance 711/95 is traditionally performed by the same AFFA as carries out the post-mortem examination, at three stages:

- At the unloading step.
- In the lairage sties with animals in repose.
- In the lairage sties with animals in movement.

Owing to increasing slaughter volumes, inspections at unloading have become unfeasible; they are now performed by a trained SIF employee (article 73), and the remaining two inspections are what effectively fall to the AFFA to do. In time studies that were performed in order to underpin the economic impact assessment, it was seen that the time spent by AFFAs on the ante-mortem task was on average 2 hours 37 minutes including document-based checking, changing uniform, going from the SIF office to the slaughter pens/sties, and on the necropsy of dead-on-arrival swine. The time that was observed ranged from 1 hour 38 minutes to 4 hours 59 minutes. Many establishments have facilities that restrict the speed of execution of the examination, such as insufficient numbers of sties for the total number of swine to be slaughtered that shift, which leads to the need for more than one evaluation per shift; a distance greater than 10 meters from the point of observation to the animals themselves; inadequate lighting with dark areas; very high overhead walkways and unsuitable flows for going from lot to lot.

Within the proposal for risk-based inspection, the ante-mortem inspection tends to be for the detection of compulsorily notifiable swine-population diseases; diseases that require mass drug treatments; diseases that affect slaughter routine by slowing down the slaughter speed, for example, or requiring adjustments to the classification teams owing to the need for official observation of the process. Individual lesions, such as cannibalism (tail bi-

ting), hernias, traumatic lesions, non-ambulatory condition, and so on, are separated out by the establishment itself, in order better to provide disposition for the affected animals and to avoid possible contamination of the slaughter process. Based on the procedures contained in “Auditing segregation procedures to isolate animals at ante-mortem and the slaughter process”, the appropriate enforcement actions will be taken if the separation procedure is inefficient. The animals are separated by lots and the AFFA inspects them in repose. The animals are only caused to move when it is necessary to examine certain individuals more closely.

Table 19 presents the results of the official ante-mortem inspection, comparing it being performed with the animals in repose, or in movement. This inspection was performed during three pilot studies on lots that had been pre-classified by the establishment at the moment of receiving live swine:

Table 19. Assessment of lesions detected in the ante-mortem inspection.

Lesion	Characteristics of the lesion	SIF A Repose	SIF A Movement	SIF B Repose	SIF B Movement	SIF C Repose	SIF C Movement
Pigs evaluated		37,319		21,039		32,616	
Abscess	Failure in classification at unloading	1 (0.000048%)				1 (0.000031%)	3 (0.000092%)
Arthritis	Failure in classification at unloading		2 (0.000054%)			1 (0.000031%)	3 (0.000092%)
Cannibalism	Failure in classification at unloading		8 (0.000214%)	2 (0.000095%)	4 (0.000190%)	2 (0.000061%)	9 (0.000276%)
Fatigue	Failure in classification at unloading						0 (0.000031%)
Bruising	Failure in classification at unloading		1 (0.000027%)				1 (0.000031%)
Dermatitis	Failure in classification at unloading	2 (0.000054%)				2 (0.000061%)	2 (0.000061%)
Emergency (stress syndrome)	Failure in classification at unloading		2 (0.000054%)				
Fractures	Failure in classification at unloading		1 (0.000027%)				
Hernia	Failure in classification at unloading		3 (0.000080%)			1 (0.000031%)	2 (0.000061%)
Traumatic lesion of feet	Failure in classification at unloading	3 (0.000080%)	3 (0.000080%)	1 (0.000048%)	2 (0.000095%)	2 (0.000061%)	2 (0.000061%)
Vesicular lesion of snout	Lesion of animal health concern	2 (0.000054%)					

Lesion	Characteristics of the lesion	SIF A Repose	SIF A Movement	SIF B Repose	SIF Movement	SIF C Repose	SIF C Movement
Pigs evaluated		37,319	21,039	32,616			
Vesicular lesion of feet	Lesion of animal health concern	18 (0.000482%)	75 (0.002010%)			1 (0.000031%)	
Otohematoma	Failure in classification at unloading		1 (0.000027%)				
Rectal prolapse	Failure in classification at unloading		5 (0.000134%)			2 (0.000061%)	1 (0.000031%)
Runts	Failure in classification at unloading			1 (0.000048%)	2 (0.000095%)		
Total		25 (0.000670%)	101 (0.002706%)	5 (0.000238%)	8 (0.000380%)	11 (0.000337%)	25 (0.000766%)

The lesions normally found in lots of swine at ante-mortem inspection in Brazil are individual occurrences that could be identified and segregated by the establishment itself, and audited by Federal Inspection in the procedures laid down in “Audit of self-control procedures in swine slaughter”. Additionally, the results shown in Table 19 demonstrate that hogs detected with any problems are rare at this stage, attaining a maximum of 0.00337%, when both in-repose and in-movement inspections are considered together.

Whereas vesicular lesions reported by the AFFAs have more to do with idiopathic swine diseases that are notified and addressed by the Animal Health Service and the executive agency in each state. Vesicles indicate a disease of populations and the identification of them is one of the objectives of ante-mortem inspection in regard to animal health surveillance. In this case, the assessment of animals in repose was sufficient to allow perception of the presence of vesicles on the hogs’ snouts and trotters in different lots, which necessitated having the animals move so that a more detailed observation could be carried out, leading to the identification of a greater number of swine carrying lesions.

Table 20 shows a comparison of the results of observations of animals in repose and in movement. It can be seen that the findings for SIFs A, B and C are proportional: SIF A has a larger slaughter volume and its self-control is less efficient in separating the animals in advance, at reception, which increases the percentage of swine that are separated, from 0.06% to 0.34%. A larger number of animals is separated when the hogs are examined in movement; however, the time spent by the AFFA in performing the assessment task is 70% greater. The time spent on this examination by an AFFA, per 8-hour shift, increases from an average 31 minutes to almost 2 hours.

Table 20. Comparative evaluation of the examination of resting animals versus animals in movement on the date of slaughter.

Item assessed	SIF A	SIF B	SIF C	Medium
Average size of a lot of hogs undergoing ante-mortem inspection/date of slaughter	3,393	3,006	1,919	2,772.7
Average percentage (%) of swine separated	0.340	0.062	0.111	0.171
Average number of hogs separated by the inspection service, in repose	2.273	0.714	0.647	1.211
Average number of hogs separated with the lot in movement	9.182	1.143	1.471	.932
Average percentage (%) of swine separated when examined in movement compared to the total number of swine separated	79.1	78.9	72.5	76.8
Average time spent by AFFA on the examination of hogs in repose (minutes per 8-hour shift)	63.4	13.4	17.8	31.5
Average time spent by AFFA on the examination of hogs in movement (minutes per 8-hour shift)	148	33.6	38.5	73.4
Average time of on-site ante-mortem inspection (minutes per 8-hour shift)	211.4	47	56.3	104.9
Average percentage of time spent (%) on the examination with animals in movement	70	71.5	68.4	69.9

In this analysis it was seen that at the unloading step, the classification and separation of the hogs for individual problems, the cleanliness of the animals, and the access that was allowed to the location, all enable an enhanced performance of the ante-mortem inspection by the AFFA. Diseases of the swine population are detected by document-based checking (transportation documentation, lot-raising records, and prior notification of the competent service) and by visual inspection of lots, both in repose and in movement, to provide details of the clinical examination. In these conditions, a significant reduction of the time spent by the AFFA on the ante mortem inspection, alongside enhanced efficiency.

Surface thermometer to identify a febrile status of swine

A laser surface thermometry method was evaluated in order to cut down on time and reduce the need for moving the animals pre-slaughter in order to check bodily temperature, replacing rectal thermometry in 188 swine that were still on the farm and in 124 during the ante mortem inspection in two slaughterhouses. Three measuring sites were compared: lateral surface of chest, back and loin. Owing to the variability of results it was impossible to recommend replacing the traditional method by surface thermometry.

Validation of post-mortem procedures

Comparison of procedures in the SIF pilot experiments

Assessments performed during the pilot studies in five SIF-inspected establishments enabled a comparison between detections in traditional inspection and those in risk-based inspection. Logistical regression analysis, taking into consideration the effects of the SIF and the procedure, was used in order to assess data for condemnation/deviation by animal part and by cause. When over-dispersion of data was found in the response variable, it was corrected by Pearson's chi-squared statistics. If separation or quasi-separation was observed in the data set, Firth's penalized maximum likelihood test was used in order to correct the analyses. Analyses were performed by LOGISTIC procedure in SAS (2012). The differences were deemed significant whenever the descriptive likelihood level of the test was lower than or equal to 5% ($p \leq 0.05$).

Table 21 shows the average percentages of condemnation and their standard errors as a function of the procedure applied to each animal part and cause of condemnation. It can be seen that logistical regression analysis did not detect a significant effect for most of the evaluations. The risk-based procedure significantly increased the detection rate for the following causes of condemnation: abscesses/purulent processes of the head; adhesions of the pleura with repercussions for the carcass; stress/fatigue-related carcass changes; hernias; spleen lesions with repercussions for the carcass; and peritonitis with repercussions for the carcass; contamination of the uterus and lesions of the uterus without repercussions for the carcass. It reduced the following causes

of condemnation: spleen lesions without repercussions for the carcass; contamination of the head; traumatic lesions of the head; hernias with repercussions for the carcass; serositis and contamination of the tongue.

As observed, the risk-based procedure, was able by and large to detect the same number of changes as the traditional procedure. Of the 13 observations with a significant effect, 6 were of increased detection by the risk-based procedure. This result may be explained by the execution of the pilot study itself, in which the full attention of the inspectors and classifiers was directed towards the performance of the tests. A reduction in detection may reflect circumstances of one particular day because the data for traditional procedures and risk-based procedures were gathered on different slaughter days, and there may have been greater thoroughness in, for example, segregating the animals at ante-mortem, affecting the post-mortem data.

Table 22 shows the average percentages for condemnation/deviation of carcasses and the corresponding standard errors as a function of the disposition and the procedure applied in each cause of condemnation. Again, it can be seen that most of the time there was no significant effect from the procedure that was carried out, and that when there was such a difference, there was usually an increase in detection and disposition.

The number of carcasses that were given the disposition of total condemnation increased by 0.17% in the risk-based procedure when compared with the traditional procedure, and in 9 out of 10 causes of condemnation there was a significant effect.

There was no significant effect on the final disposition caused by the inspection procedure of removing the affected part of the carcass. There were 5 situations in which there was a significant effect of the inspection procedure: of these, 3 showed increased detection in the risk-based procedure (Table 21).

Disposition to heat treatment: the risk-based inspection procedure increased the total number of carcasses by 0.50%; for 7 causes, the increase occurred in the risk-based procedure, and for 2 it occurred in the traditional procedure.

Taking the results all together, it can be concluded that there is no increased risk to the consumer from executing the risk-based sanitary inspection procedures recommended in this document.

Table 21. Comparison between the traditional procedure and the risk-based procedure by average and standard deviation of the percentage for condemnation/deviation according to procedure and descriptive levels of likelihood in the logistic regression.

Cause of condemnation	Procedure		Pr> χ^2
	Traditional	Risk-based	
Number of animals slaughtered	250,251	179,953	-
Animal			
Dead (on arrival or in lairage)	0.0576± 0.0316	0.0579± 0.0278	0.7027
Total	0.0576± 0.0316	0.0579± 0.0278	0.7027
Spleens			
Contamination	3.7229± 0.9727	3.3020± 1.4084	0.6908
Spleen lesion without repercussions for the carcass	0.4590± 0.4247	0.0207± 0.0127	0.0516
Total	4.1818± 1.1921	3.3227± 1.4173	0.5437
Heads			
Abscesses/purulent processes	0.0134± 0.0134	0.0221± 0.0167	0.0547
Contamination	4.6304± 2.3133	2.8479± 1.8999	0.0189
Traumatic lesion	0.5126± 0.5126	0.0215± 0.0215	<0.0001
Total	5.1564± 2.7555	2.8915± 1.9356	0.0084
Carcasses			
Abscess (tail biting)	0.2100± 0.1121	0.2222± 0.0971	0.5209
Abscesses/purulent processes	1.2762± 0.4958	1.7119± 0.3374	0.1332
Pleural adhesions (resolved)	6.1628± 1.1713	7.6423± 3.3577	0.9604
Pleural adhesion with repercussions for the carcass	0.0264± 0.0258	0.3303± 0.2302	0.0023
Changes due to stress/fatigue	0.0000± 0.0000	0.0018± 0.0018	0.0451
Anemia/pallor	0.0257± 0.0168	0.0260± 0.0214	0.2250
Arthritis	0.1393± 0.0634	0.1212± 0.0429	0.8350
Ascites	0.0006± 0.0006	0.0000± 0.0000	0.2383
Contamination	2.7095± 1.3092	2.4022± 0.8261	0.0958
Dermatitis/skin lesion/mange	0.3273± 0.1288	0.2804± 0.1293	0.1971
Endocarditis	0.0026± 0.0016	0.0034± 0.0023	0.4945
Enteritis with repercussions for the carcass	0.0441± 0.0259	0.0302± 0.0126	0.7345

Cause of condemnation	Procedure		Pr> χ^2
	Traditional	Risk-based	
Carcasses			
Erysipelas	0.0025± 0.0025	0.0000± 0.0000	0.0554
Delayed evisceration	0.0194± 0.0176	0.0107± 0.0085	0.5914
Failure at scalding/dehairing/singeing/splitting	0.6949± 0.1272	0.6144± 0.1702	0.1198
Failures in castration	0.0067± 0.0067	0.0000± 0.0000	0.1223
Hernia without repercussions for the carcass	0.3715± 0.2425	0.4824± 0.2004	0.0271
Hernia with repercussions for the carcass	0.0760± 0.0573	0.0333± 0.0205	0.0036
Jaundice	0.0082± 0.0054	0.0037± 0.0021	0.0701
Spleen lesion with repercussions for the carcass	0.0140± 0.0073	0.0384± 0.0199	<0.0001
Liver lesion with repercussions for the carcass	0.0000± 0.0000	0.0006± 0.0006	0.1497
Lung lesion with repercussions for the carcass	0.7415± 0.1378	0.5859± 0.1519	0.8816
Kidney lesion with repercussions for the carcass	0.0000± 0.0000	0.0000± 0.0000	-
Traumatic lesion	4.0562± 1.5705	3.6449± 1.2710	0.3790
Lymphadenitis	0.7420± 0.3549	1.4181± 0.7807	0.1477
Leanness/cachexia	0.0826± 0.0214	0.0960± 0.0177	0.0614
Neoplasia	0.0026± 0.0011	0.0050± 0.0031	0.1040
Pericarditis with repercussions for the carcass	0.0000± 0.0000	0.0000± 0.0000	-
Acute peritonitis	0.0816± 0.0710	0.0931± 0.0905	0.6037
Peritonitis with repercussions for the carcass	0.0229± 0.0175	0.0500± 0.0496	<0.0001
Incomplete bleeding	0.0000± 0.0000	0.0000± 0.0000	-
Serositis	0.0261± 0.0179	0.0124± 0.0124	0.0444
Total	17.8732± 2.8603	19.8609± 4.6954	0.7044
Hearts			
Contamination	5.6142± 3.2770	4.5484± 2.8606	0.2822
Heart lesion without repercussions for the carcass	6.5673± 0.7345	7.2521± 0.9082	0.1927
Total	12.1815± 3.4452	11.8005± 3.2753	0.8933

Cause of condemnation	Procedure		Pr> χ^2
	Traditional	Risk-based	
Livers			
Contamination	5.6080± 3.0086	1.5803± 0.6615	0.1900
Liver lesion without repercussion for the carcass	16.2191± 5.1217	12.6987± 7.7822	0.7130
Total	21.8272± 7.1483	14.2790± 7.7178	0.9530
Intestines/stomachs			
Contamination	7.9031± 3.2514	7.6171± 2.4618	0.8232
Lesion of green viscera without repercussions for the carcass	1.9694± 1.2416	1.9594± 1.0931	0.7870
Total	9.8725± 4.3431	9.5765± 3.4360	0.7207
Tongues			
Contamination	5.8323± 3.4316	0.0000± 0.0000	<0.0001
Total	5.8323± 3.4316	0.0000± 0.0000	<0.0001
Lungs			
Aspiration of liquid	24.7882±16.4795	23.4665±16.4277	0.7546
Contamination	5.7296± 3.0229	4.6501± 2.6356	0.1627
Lung lesion without repercussions for the carcass	16.6343± 6.3000	13.6867± 4.8476	0.4629
Total	47.1521±13.6038	41.8034±15.0413	0.4935
Kidneys			
Contamination	7.2337± 5.0893	0.7870± 0.6892	0.0613
Kidney lesion without repercussion for the carcass	28.7436± 8.3942	12.1867± 6.2219	0.2217
Total	35.9773±13.2767	12.9737± 6.8022	0.2113
Uterus			
Contamination	0.8237± 0.8216	1.3844± 1.3844	<0.0001
Uterus lesion without repercussion for the carcass	0.4943± 0.4943	0.7808± 0.7808	<0.0001
Total	1.3180± 1.3159	2.1652± 2.1652	<0.0001

Table 22. Comparison between the traditional procedure and the risk-based procedure by average and standard deviation of the percentage for condemnation/deviation according to procedure and descriptive levels of likelihood in the logistic regression.

Cause of condemnation	Procedure		Pr> χ^2
	Traditional	Risk-based	
Number of animals slaughtered	250.251	179.953	-
Total condemnation			
Abscess (tail biting)	0.0077± 0.0077	0.0059± 0.0034	0.1690
Abscesses/purulent processes	0.1225± 0.0592	0.1631± 0.0787	0.0397
Pleural adhesions with repercussions for the carcass	0.0005± 0.0005	0.0208± 0.0160	<0.0001
Anemia/pallor	0.0206± 0.0176	0.0239± 0.0218	0.3688
Arthritis	0.0142± 0.0081	0.0398± 0.0330	0.0329
Ascites	0.0006± 0.0006	0.0000± 0.0000	0.2383
Contamination	0.1417± 0.0544	0.1977± 0.0820	0.0143
Dermatitis/skin lesion/mange	0.0067± 0.0067	0.0114± 0.0107	0.0713
Endocarditis	0.0003± 0.0003	0.0004± 0.0004	0.7194
Enteritis with repercussions for the carcass	0.0017± 0.0017	0.0050± 0.0042	0.1048
Erysipelas	0.0006± 0.0006	0.0000± 0.0000	0.2765
Delayed evisceration	0.0179± 0.0179	0.0100± 0.0087	0.6234
Failure at scalding/ dehairing/ singeing/splitting	0.0201± 0.0193	0.0346± 0.0286	0.0013
Failures in castration	0.0000± 0.0000	0.0000± 0.0000	-
Hernia with repercussions for the carcass	0.0534± 0.0526	0.0138± 0.0122	<0.0001
Jaundice	0.0082± 0.0054	0.0037± 0.0021	0.0701
Spleen lesion with repercussions for the carcass	0.0080± 0.0076	0.0192± 0.0180	0.0003
Lung lesion with repercussions for the carcass	0.1336± 0.0635	0.1214± 0.0794	0.2006
Traumatic lesion	0.0209± 0.0201	0.0444± 0.0429	<0.0001
Lymphadenitis	0.0492± 0.0492	0.0745± 0.0745	0.0002
Leanness/cachexia	0.0036± 0.0020	0.0122± 0.0064	0.0009
Neoplasia	0.0023± 0.0010	0.0026± 0.0022	0.9276

Cause of condemnation	Procedure		Pr> χ^2
	Traditional	Risk-based	
Pericarditis with repercussions for the carcass	0.0000± 0.0000	0.0000± 0.0000	-
Acute peritonitis	0.0816± 0.0710	0.0931± 0.0905	0.6037
Incomplete bleeding	0.0000± 0.0000	0.0000± 0.0000	-
Total	0.7161± 0.3034	0.8977± 0.4628	0.0028
Removal of the affected part			
Abscess (tail biting)	0.1394± 0.0817	0.1944± 0.0896	0.0414
Abscesses/purulent processes	1.0654± 0.5228	1.1869± 0.4463	0.8947
Pleural adhesion (resolved) without repercussions for the carcass	6.1628± 1.1713	7.6423± 3.3577	0.9604
Arthritis	0.0753± 0.0450	0.0461± 0.0201	0.0630
Contamination	2.5399± 1.3134	2.1913± 0.8528	0.0451
Dermatitis/skin lesion/mange	0.3195± 0.1256	0.2578± 0.1292	0.1336
Enteritis with repercussions for the carcass	0.0009± 0.0009	0.0000± 0.0000	0.1556
Failure at scalding/dehairing/singeing	0.6742± 0.1111	0.5754± 0.1704	0.0917
Hernia without repercussions for the carcass	0.3715± 0.2425	0.4824± 0.2004	0.0271
Spleen lesion with repercussions for the carcass	0.0019± 0.0019	0.0040± 0.0040	0.1387
Liver lesion with repercussions for the carcass	0.0000± 0.0000	0.0006± 0.0006	0.1497
Traumatic lesion	3.8727± 1.6311	3.4182± 1.3076	0.5791
Lymphadenitis	0.6144± 0.2848	1.1540± 0.8058	0.2133
Neoplasia	0.0003± 0.0003	0.0024± 0.0024	0.0208
Serositis	0.0261± 0.0179	0.0124± 0.0124	0.0444
Total	15.8642± 3.0113	17.1682± 5.0429	0.9951
Heat treatment			
Abscess (tail biting)	0.0628± 0.0385	0.0219± 0.0163	0.0054
Abscesses/purulent processes	0.0883± 0.0552	0.3619± 0.3298	0.0001
Pleural adhesion with repercussions for the carcass	0.0259± 0.0259	0.3095± 0.2308	0.0024

Cause of condemnation	Procedure		Pr> χ^2
	Traditional	Risk-based	
Changes due to stress/fatigue	0.0000± 0.0000	0.0018± 0.0018	0.0451
Anemia/pallor	0.0050± 0.0050	0.0021± 0.0021	0.1788
Arthritis	0.0498± 0.0246	0.0353± 0.0109	0.4019
Contamination	0.0279± 0.0237	0.0132± 0.0124	0.0006
Dermatitis/skin lesion/mange	0.0011± 0.0008	0.0111± 0.0080	<0.0001
Endocarditis	0.0023± 0.0015	0.0030± 0.0019	0.5228
Enteritis with repercussions for the carcass	0.0415± 0.0242	0.0252± 0.0117	0.7196
Erysipelas	0.0019± 0.0019	0.0000± 0.0000	0.0814
Delayed evisceration	0.0015± 0.0015	0.0007± 0.0007	0.3644
Failure at scalding/ dehairing/ singeing	0.0006± 0.0006	0.0043± 0.0039	0.0062
Failures in castration	0.0067± 0.0067	0.0000± 0.0000	0.1223
Hernia with repercussions for the carcass	0.0226± 0.0159	0.0194± 0.0135	0.4430
Jaundice	0.0000± 0.0000	0.0000± 0.0000	-
Spleen lesion with repercussions for the carcass	0.0041± 0.0041	0.0152± 0.0152	<0.0001
Lung lesion with repercussions for the carcass	0.6079± 0.1188	0.4644± 0.1349	0.8447
Kidney lesion with repercussions for the carcass	0.0000± 0.0000	0.0000± 0.0000	-
Traumatic lesion	0.1625± 0.1013	0.1824± 0.0504	0.6313
Lymphadenitis	0.0784± 0.0784	0.1896± 0.1110	0.1848
Leanness/cachexia	0.0790± 0.0233	0.0838± 0.0240	0.3892
Neoplasia	0.0000± 0.0000	0.0000± 0.0000	-
Pericarditis with repercussions for the carcass	0.0000± 0.0000	0.0000± 0.0000	-
Peritonitis with repercussions for the carcass	0.0229± 0.0175	0.0500± 0.0496	<0.0001
Incomplete bleeding	0.0000± 0.0000	0.0000± 0.0000	-
Total	1.2929± 0.2595	1.7951± 0.3538	<0.0001

Time study of activities exclusively pertaining to the AFFA in the ante and post-mortem inspection of swine

As the pilot tests were conducted, the time spent by the AFFA on ante-mortem and post-mortem activities was measured. The results are shown in Tables 23, 24, 25 and 26.

Time-keeping specialists measured the minimum necessary activities to perform exclusively the ante-mortem and post-mortem tasks that would be the exclusive prerogative of AFFAs who have graduated in Veterinary Medicine. Other tasks such as the official Verification of Self-Controls, sample-taking, and domestic and international health certificates, were not taken into consideration. The necessary intervals for meals, the necessary legally-mandated rest breaks, and public holidays, periods of leave, time spent off-work, and absences - whether scheduled or otherwise - were excluded from the calculation. Out of tolerance for variability, 10% was added to the task-performance times.

One specific study compared times spent on ante-mortem inspections on animals in repose (step 4 of the task) versus in movement (step 5 of the task). It was observed that the time spent on the in-motion inspection increases the work of the AFFA a great deal, while returning the greater quantity of detections of certain lesions and defects in the animals. However, since the changes that are observed are amenable to detection during classification during the unloading step, and the quality of this classification will undergo official auditing inside the slaughterhouse, it is suggested that the examination be performed with the animals in repose. The ante-mortem inspection should be an opportunity for evaluating the lot in safety, focusing on population diseases of concern to official Animal Health Programs and posing risks for public health. The identification of individual lesions that may contaminate the slaughter process should be attributed to the company's technical responsibility.

In the scenario specified in Table 23, traditional inspection demands 13 hours 38 minutes of the AFFA, who has a work load of 8 hours per day and 40 hours per week, with at least one hour for a meal break. Applying a risk-based inspection system, the inclusion of ten audit tasks - the assessment and classification of lesions and defects on the production lines - is observed, which adds 92 minutes per shift. Exclusion of the mandatory ante-mortem inspection

activities with the animals in movement takes off 163 minutes per shift. In turn, the exclusion of the handling, judging and incision of carcasses in which the lesions and defects are not related to important hazards for public health, equals a further reduction of 462 minutes per shift. Totalizing these changes reduces demand by almost 9 hours' work, and a time of 4h45min remains for addressing ante-mortem and post-mortem. The working occupancy rate of AFFAs is expected to fall from an unfeasible 162% to around 56% of working time with the ante-mortem and post-mortem activities, and this enables the execution of other tasks and the break times that are necessary for their well-being.

In the case reported in Table 23 (SIF A), it should be observed that the establishment's previous evaluation and classification of animals left something to be desired owing to the deficient cleanliness of the animals at unloading, thus involving the AFFA with the separation of several animals. The structural condition of the establishment (visual access to the hogs) and the need to break up the ante-mortem inspection into two different moments on each shift (undersizing of the lairage sties) also increased the time spent by the AFFA. Compared with Table 24, the slightly lower number of hogs was assessed within a much shorter time frame, owing to the greater efficiency of the classifiers in separating the animals, and to the structure, which allowed all the animals to be assessed in a single visit to the sties.

In the scenario shown in Table 24, it can be seen that even with a similar capacity, the assessment times reported for steps 4 and 5 of the tasks are significantly shorter than the same steps as demonstrated in Form 14. The reduction in inspection time can be attributed to the efficient classification and cleaning of hogs at the unloading step and to the possibility of inspecting the 3,000 housed animals in a single visit, as well as to the structure of the sties allowing visual access to the animals without the need for overhead walkways and double walking flows. The reduction in the time demand from 9 hours 11 minutes to 3 hours 57minutes (Table 24) provided a time of 5 hours and 14 minutes for the execution of other tasks and allowed the breaks that are necessary for the well-being of the AFFA.

In Table 25 it can be seen that at lower velocities the reduction of time-occupation is smaller, albeit still significant. Finally, the scenario shown in Table 26 shows that at lower velocities the AFFA's time-occupation rate increases as a function mainly of the evaluation and classification audits that take longer to perform, given that the same sampling rate of 60 carcasses or operations per day is still demanded. Nonetheless, the estimate time-occupation rate is still adjusted to the AFFA's available time for the activity.

It is therefore concluded that when the procedures laid down for risk-based inspection are applied, and even when "evaluation and classification" auditing activities are included on the production lines, a significant reduction in the amount of time spent by the AFFA on ante-mortem and post-mortem inspections is expected. The reduction in the time does not jeopardize the sensitivity of the evaluations, while it enhances the availability of time for executing the remaining inspection tasks, such as verifications of self-controls and issuing certification: although the latter were not the target of the present analysis, they are of fundamental importance in ensuring consumers' health.

Table 23. Comparative evaluation of the examination of resting animals versus animals in movement on the date of slaughter.

Steps of the task	Tasks	TASK - ANTE-MORTEM INSPECTION				Impact
		Traditional	Traditional adjusted ¹	Risk-based	Risk-based adjusted ¹	
Operator: Veterinarian (SIF)						
Activities of ante-mortem inspection						
1	Change of uniform (blue)	5	5	5	5	0
2	Travel	10	10	10	10	0
3	Document-based verification	15	17	15	17	0
4	Inspecting pigs in repose	64	70	64	70	0
5	Inspecting pigs in motion	148	163	0	0	-163
6	Necropsy (5 min/pig, post-loading mortality of 0.06%)	11	12	11	12	0
7	Inspecting segregated swine (1 min/pig, segregated 0.3%)	11	12	11	12	0
8	Travel	10	10	10	10	0
TASK - POST-MORTEM INSPECTION						
Operator: Veterinarian (SIF)						
Evaluation and classification activities of audits						
9	Change of uniform (white)	8	8	8	8	0
10	Travel	5	5	5	5	0
11	Audit at live animal receiving, evaluation and classification steps (pre-evisceration) (60 carcasses)	0	0	7	8	8

¹Out of tolerance for variability, 10% was added to the task-performance times.

Steps of the task	Tasks	Traditional	Traditional adjusted ¹	Risk-based	Risk-based adjusted ¹	Impact
12	Evaluation audit of evisceration process (post-splitting carcasses) (60 carcasses)	0	0	7	8	8
13	Audit of evaluation and classification of carcasses and heads (60 procedures)	0	0	7	8	8
14	Audit of evaluation and classification of hearts (60 procedures)	0	0	7	8	8
15	Audit of evaluation and classification of lungs (60 procedures)	0	0	7	8	8
16	Audit of evaluation and classification of livers (60 procedures)	0	0	7	8	8
17	Audit of evaluation and classification of green viscera (60 procedures)	0	0	7	8	8
18	Audit of evaluation and classification of kidneys (60 procedures)	0	0	7	8	8
19	Audit of evaluation and classification in DEC by RV	0	0	10	11	11
20	Audit of detention deboning (once weekly)	0	0	15	17	17
Operator: Veterinarian (SIF)						
Activities of post-mortem inspection						
21	Execution by DIF (0.67 min/carcass - 18.5% deviation with 1.1 % lymphadenitis)	446	491	29	29	-462
22	Change of clothing (civilian)	15	15	15	15	0
	Total time (h)	12:28	13:38	4:24	4:45	8:53

¹Out of tolerance for variability, 10% was added to the task-performance times.

Table 24. Estimated time (in minutes) needed in order to perform the tasks of an AFFA in one slaughter shift at a velocity of 400 hogs/hour and capacity of 3,000 hogs per shift - SIF B.

Steps of the task	Tasks	Time (Min)				
		Traditional	Traditional adjusted ¹	Risk-based	Risk-based adjusted ¹	Impact
TASK - ANTE MORTEM INSPECTION						
Operator: Veterinarian (SIF)						
Activities of ante-mortem inspection						
1	Change of uniform (blue)	5	5	5	5	0
2	Travel	10	10	10	10	0
3	Document-based verification	15	17	15	17	0
4	Inspecting pigs in repose	14	15	14	15	0
5	Inspecting pigs in motion	34	37	0	0	-37
6	Necropsy (5 min/pig, post-loading mortality of 0.06%)	9	10	9	10	0
7	Inspecting segregated swine (1 min/pig, segregated 0.3%)	9	10	9	10	0
8	Travel	10	10	10	10	0

¹Out of tolerance for variability, 10% was added to the task-performance times.

Steps of the task	Tasks	Time (Min)				Impact
		Traditional	Traditional adjusted ¹	Risk-based	Risk-based adjusted ¹	
TASK - POST-MORTEM INSPECTION						
Operator: Veterinarian (SIF)						
Evaluation and classification activities of audits						
9	Change of uniform (white)	8	8	8	8	0
10	Travel	5	5	5	5	0
11	Audit at live animal receiving, evaluation and classification steps (pre-evisceration) (60 carcasses)	0	0	9	10	10
12	Evaluation audit of evisceration process (post-splitting carcass) (60 carcasses)	0	0	9	10	10
13	Audit of evaluation and classification of carcasses and heads (60 procedures)	0	0	9	10	10
14	Audit of evaluation and classification of hearts (60 procedures)	0	0	9	10	10
15	Audit of evaluation and classification of hearts (60 procedures)	0	0	9	10	10
16	Audit of evaluation and classification of livers (60 procedures)	0	0	9	10	10
17	Audit of evaluation and classification of green viscera (60 procedures)	0	0	9	10	10

¹Out of tolerance for variability, 10% was added to the task-performance times.

Steps of the task	Tasks	Time (Min)				Impact
		Traditional	Traditional adjusted ¹	Risk-based	Risk-based adjusted ¹	
18	Audit of evaluation and classification of kidneys (60 procedures)	0	0	9	10	10
19	Audit of evaluation and classification in DEC by RV	0	0	10	11	11
20	Audit of detention deboning (once weekly)	0	0	15	17	17
	Operator: Veterinarian (SIF)					
	Operator: Veterinarian (SIF)					
21	Execution by DIF (0.67 min/carcass - 18.5% deviation with 1.1% lymphadenitis)	372	409	24	24	-385
22	Change of clothing (civilian)	15	15	15	15	0
	Total time (h)	8:26	9:11	3:41	3:57	5:14

¹Out of tolerance for variability, 10% was added to the task-performance times.

Table 25. Estimated time (in minutes) needed to perform the tasks of an AFFA in a hog-slaughtering shift at a velocity of 310 hogs per hour and a capacity of 2,000 hogs - SIF C.

Steps of the task	Tasks	Time (Min)			Impact
		Traditional	Risk-based adjusted ¹	Risk-based adjusted ¹	
TASK - ANTE-MORTEM INSPECTION					
Operator: Veterinarian (SIF)					
Activities of ante-mortem inspection					
1	Change of uniform (blue)	5	5	5	0
2	Travel	10	10	10	0
3	Document-based verification	15	17	17	0
4	Inspecting pigs in repose	18	20	18	0
5	Inspecting pigs in motion	39	43	0	-43
6	Necropsy (5 min/pig, post-loading mortality of 0.06%)	6	7	6	7
7	Inspecting segregated swine (1 min/pig, segregated 0.3%)	6	7	6	7
8	Travel	10	10	10	0

¹Out of tolerance for variability, 10% was added to the task-performance times.

Steps of the task	Tasks	Time (Min)				Impact
		Traditional	Traditional adjusted ¹	Risk-based	Risk-based adjusted ¹	
TASK - POST-MORTEM INSPECTION						
Operator: Veterinarian (SIF)						
Evaluation and classification activities of audits						
9	Change of uniform (white)	8	8	8	8	0
10	Travel	5	5	5	5	0
11	Audit at live animal receiving, evaluation and classification steps (pre-evisceration) (60 carcasses)	0	0	12	13	13
12	Evaluation audit of evisceration process (post-splitting carcass) (60 carcasses)	0	0	12	13	13
13	Audit of evaluation and classification of carcasses and heads (60 procedures)	0	0	12	13	13
14	Audit of evaluation and classification of hearts (60 procedures)	0	0	12	13	13
15	Audit of evaluation and classification of lungs (60 procedures)	0	0	12	13	13
16	Audit of evaluation and classification of livers (60 procedures)	0	0	12	13	13
17	Audit of evaluation and classification of green viscera (60 procedures)	0	0	12	13	13

¹Out of tolerance for variability, 10% was added to the task-performance times.

Steps of the task	Tasks	Time (Min)					Impact
		Traditional	Traditional adjusted ¹	Risk-based	Risk-based adjusted ¹	Risk-based adjusted ¹	
18	Audit of evaluation and classification of kidneys (60 procedures)	0	0	12	13	13	13
19	Audit of evaluation and classification in DEC by RV	0	0	10	11	11	11
20	Audit of detention deboning (once weekly)	0	0	15	17	17	17
	Operator: Veterinarian (SIF)						
	Inspection activities						
21	Execution by DIF (0.67 min/carcaass - 18.5% deviation with 1.1% lymphadenitis)	248	273	16	16	16	-257
22	Change of clothing (civilian)	15	15	15	15	15	0
	Total time (h)	6:25	7:00	3:55	4:12	4:12	2:48

¹Out of tolerance for variability, 10% was added to the task-performance times.

Table 26. Estimated time (in minutes) needed in order to perform the tasks of an AFFA in one hog-slaughtering shift at a velocity of 160 hogs/hour and capacity of 800 hogs per shift - SIF D.

Steps of the task	Tasks	Time (Min)			Impact
		Traditional	Risk-based adjusted ¹	Risk-based adjusted ¹	
TASK - ANTE-MORTEM INSPECTION					
Operator: Veterinarian (SIF)					
Activities of ante-mortem inspection					
1	Troca de roupa (azul)	5	5	5	0
2	Travel	10	10	10	0
3	Document-based verification	15	17	17	0
4	Inspecting pigs in repose	14	15	14	0
5	Inspecting pigs in motion	34	37	0	-37
6	Necropsy (5 min/pig, post-loading mortality of 0.06%)	2	2	2	0
7	Inspecting segregated swine (1 min/pig, segregated 0.3%)	2	2	2	0
8	Travel	10	10	10	0

¹Out of tolerance for variability, 10% was added to the task-performance times.

Steps of the task	Tasks	Time (Min)				Impact
		Traditional	Traditional adjusted ¹	Risk-based	Risk-based adjusted ¹	
TASK - POST-MORTEM INSPECTION						
Operator: Veterinarian (SIF)						
Evaluation and classification activities of audits						
9	Change of uniform (white)	8	8	8	8	0
10	Travel	5	5	5	5	0
11	Audit at live animal receiving, evaluation and classification steps (pre-evisceration) (60 carcasses)	0	0	23	25	25
12	Evaluation audit of evisceration process (post-splitting carcass) (60 carcasses)	0	0	23	25	25
13	Audit of evaluation and classification of carcasses and heads (60 procedures)	0	0	23	25	25
14	Audit of evaluation and classification of hearts (60 procedures)	0	0	23	25	25
15	Audit of evaluation and classification of lungs (60 procedures)	0	0	23	25	25
16	Audit of evaluation and classification of livers (60 procedures)	0	0	23	25	25
17	Audit of evaluation and classification of green viscera (60 procedures)	0	0	23	25	25

¹Out of tolerance for variability, 10% was added to the task-performance times.

Steps of the task	Tasks	Time (Min)				Impact
		Traditional	Traditional adjusted ¹	Risk-based	Risk-based adjusted ¹	
18	Audit of evaluation and classification of kidneys (60 procedures)	0	0	23	25	25
19	Audit of evaluation and classification in DEC by RV	0	0	10	11	11
20	Audit of detention deboning (once weekly)	0	0	15	17	17
	Operator: Veterinarian (SIF)					
	Inspection activities					
21	Execution by DIF (0.67 min/carcaass - 18.5% deviation with 1.1% lymphadenitis)	99	109	6	6	-103
22	Change of clothing (civilian)	15	15	15	15	0
	Total time(h)	3:39	3:55	5:01	5:23	1:28

¹Out of tolerance for variability, 10% was added to the task-performance times.

Time study of the activities of an RV and high-school graduate professionals (official and private personnel) at post-mortem

Good execution of the post-mortem examination activities of inspection and classification depends on a fit between the time available for the execution of the task and the time during which the target of the evaluation (viscera or carcasses etc.) remains available to the operator. This match must take into consideration the automatic propulsion of the trays and of the carcasses on hooks on the rail, and the particularities of the work of evaluation, classification and inspection of the viscera. The time needed for each task was therefore measured, and an adjustment of 10% given for individual variations, and the number of units produced by each operator per hour was stipulated (UPHh). These data enabled a calculation of the total number of possible processing pieces per hour; comparing this to the slaughter speed per hour, the necessary workforce (WF) was determined. This value was stipulated for each slaughter scenario, and in this case it was observed that the slaughter speed has a fundamental influence on the need for labor, as shown in Tables 27, 28, 29 and 30. For the RV, to calculate the necessary time, the extreme values of 18.5% deviations and 1.1% lymphadenitis, were assumed.

Table 27. Estimate of the workforce needed in order to carry out the tasks on the inspection lines performed by high-school level personnel and at post-mortem by the RV at a slaughter of 550 hogs per hour - SIF A.

Steps of the task	Tasks	Traditional inspection			Risk-based inspection					
		Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	
Operator: Inspection auxiliary										
Intestine inspection activities										
1	Change of uniform (white)									
2	Inspecting the lymph node chain	10	11.00	327	1.7	16.0	17.60	205	2.7	
3	Change of clothing (civilian)									
Operator: RV auxiliary										
Evaluation and classification activities										
1	Heads	12.7	14.0	258	2.1	6.4	7.0	511	1.1	
2	Jowl	5.6	6.2	584	0.9	0.0	0.0			
3	Tongues	7.3	8.0	448	1.2	0.0	0.0			
4	Green offals	6.6	7.3	496	1.1	6.6	7.3	496	1.1	
5	Hearts	13.1	14.4	250	2.2	6.9	7.6	474	1.2	
6	Lungs	12.9	14.2	254	2.2	6.7	7.4	488	1.1	
7	Livers	5.9	6.5	555	1.0	5.9	6.5	555	1.0	
8	Kidney (optional)	6.4	7.0	511	1.1	0.0	0.0			
9	Evaluation of carcass (classification in DEC)	6.7	7.4	488	1.1	6.7	7.4	488	1.1	
10	Harvesting diaphragm/testing for trichinellosis	5.9	6.5	555	1.0	5.9	6.5	555	1.0	

Steps of the task	Tasks	Traditional inspection			Risk-based inspection				
		Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF
	Operator: Responsible Veterinarian								
	Supplementary examination in the DEC								
1	Evaluation and classification of carcasses in the DEC (40 sec/ carcass - 18.5% deviation - 1.1% lymphadenitis)		40.0	82		44.0	82		1.2
2	Sanitary management of slaughter procedures								
	Minimum number of high-school graduate staff - Official service							15.6	2.7
	Minimum number of high-school graduate staff - Company							0	7.6

¹ Out of tolerance for variability, 10% was added to the task-performance times.

UPHh: number of Units Produced per operator per Hour.

WF: necessary workforce.

Table 28. Estimate of the workforce needed in order to carry out the tasks on the inspection lines performed by high-school level personnel and at post-mortem by the RV at a slaughter of 400 hogs per hour - SIF B.

Steps of the task	Tasks	Traditional inspection			Risk-based inspection					
		Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	
Operator: Inspection Auxiliary										
Intestine inspection activities										
1	Change of uniform (white)									
2	Inspecting the lymph node chain	10	11.00	327	1.2	16.0	17.60	205	2.0	
3	Change of clothing (civilian)									
Operator: RV auxiliary										
Evaluation and classification activities										
1	Heads	12.7	14.0	258	1.6	6.4	7.0	511	0.8	
2	Jowl	5.6	6.2	584	0.7	0.0	0.0			
3	Tongues	7.3	8.0	448	0.9	0.0	0.0			
4	Green offals	6.6	7.3	496	0.8	6.6	7.3	496	0.8	
5	Hearts	13.1	14.4	250	1.6	6.9	7.6	474	0.8	
6	Lungs	12.9	14.2	254	1.6	6.7	7.4	488	0.8	
7	Livers	5.9	6.5	555	0.7	5.9	6.5	555	0.7	
8	Kidney (optional)	6.4	7.0	511	0.8	0.0	0.0			
9	Evaluation of Carcass (classification in DEC)	6.7	7.4	488	0.8	6.7	7.4	488	0.8	

Steps of the task	Tasks	Traditional inspection				Risk-based inspection			
		Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF
10	Harvesting diaphragm/testing for trichinellosis	5.9	6.5	555	0.7	5.9	6.5	555	0.7
	Operator: Responsible Veterinarian								
	Supplementary examination in the DEC								
1	Evaluation and classification of carcasses in the DEC (40 sec/ carcass - 18.5% deviation -1.1% lymphadenitis)					40.0	44.0	82	0.9
2	Sanitary management of slaughter procedures								
	Minimum number of high-school graduate staff - Official service							11.4	2.0
	Minimum number of high-school graduate staff - Company							0	5.5

¹ Out of tolerance for variability, 10% was added to the task-performance times.

UPHh: number of Units Produced per operator per Hour.

WF: necessary workforce.

Table 29. Estimate of the workforce needed in order to carry out the tasks on the inspection lines performed by high-school level personnel and at post-mortem by the RV at a slaughter of 310 hogs per hour - SIF C.

Steps of the task	Tasks	Traditional inspection			Risk-based inspection					
		Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	
Operator: Inspection auxiliary										
Intestine inspection activities										
1	Change of uniform (white)									
2	Inspecting the lymph node chain	10	11.00	327	0.9	16.0	17.60	205	1.5	
3	Change of clothing (civilian)									
Operator: RV auxiliary										
Evaluation and classification activities										
1	Heads	12.7	14.0	258	1.2	6.4	7.0	511	0.6	
2	Jowl	5.6	6.2	584	0.5	0.0	0.0			
3	Tongues	7.3	8.0	448	0.7	0.0	0.0			
4	Green offals	6.6	7.3	496	0.6	6.6	7.3	496	0.6	
5	Hearts	13.1	14.4	250	1.2	6.9	7.6	474	0.7	
6	Lungs	12.9	14.2	254	1.2	6.7	7.4	488	0.6	
7	Livers	5.9	6.5	555	0.6	5.9	6.5	555	0.6	
8	Kidney (optional)	6.4	7.0	511	0.6	0.0	0.0			
9	Evaluation of carcass (classification in DEC)	6.7	7.4	488	0.6	6.7	7.4	488	0.6	
10	Harvesting diaphragm/testing for trichinellosis	5.9	6.5	555	0.6	5.9	6.5	555	0.6	

Steps of the task	Tasks	Traditional inspection			Risk-based inspection				
		Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF
	Operator: Responsible Veterinarian								
	Supplementary examination in the DEC								
1	Evaluation and classification of carcasses in the DEC (40 sec/ carcass - 18.5% deviation - 1.1% lymphadenitis)		40.0	82		44.0	82		0.7
2	Sanitary management of slaughter procedures								
	Minimum number of high-school graduate staff - Official service							8.8	1.5
	Minimum number of high-school graduate staff - Company							0	4.3

¹ Out of tolerance for variability, 10% was added to the task-performance times.

UPHh: number of Units Produced per operator per Hour.

WF: necessary workforce.

Table 30. Estimate of the workforce needed in order to carry out the tasks on the inspection lines performed by high-school level personnel and at post-mortem by the RV at a slaughter of 160 hogs per hour - SIF D.

Steps of the task	Tasks	Traditional inspection				Risk-based inspection				
		Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	
Operator: Inspection auxiliary										
Intestine inspection activities										
1	Change of uniform (white)									
2	Inspecting the lymph node chain	10	11.00	327	0.5	16.0	17.60	205	0.8	
3	Change of clothing (civilian)									
Operator: RV auxiliary										
Evaluation and classification activities										
1	Heads	12.7	14.0	258	0.6	6.4	7.0	511	0.3	
2	Jowl	5.6	6.2	584	0.3	0.0	0.0			
3	Tongues	7.3	8.0	448	0.4	0.0	0.0			
4	Green offals	6.6	7.3	496	0.3	6.6	7.3	496	0.3	
5	Hearts	13.1	14.4	250	0.6	6.9	7.6	474	0.3	
6	Lungs	12.9	14.2	254	0.6	6.7	7.4	488	0.3	
7	Livers	5.9	6.5	555	0.3	5.9	6.5	555	0.3	
8	Kidney (optional)	6.4	7.0	511	0.3	0.0	0.0			
9	Evaluation of carcass (classification in DEC)	6.7	7.4	488	0.3	6.7	7.4	488	0.3	
10	Harvesting diaphragm/testing for trichinellosis	5.9	6.5	555	0.3	5.9	6.5	555	0.3	

Steps of the task	Tasks	Traditional inspection			Risk-based inspection				
		Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF	Time (sec/pig)	Adjusted time (sec/pig) ¹	UPHh	WF
	Operator: Responsible Veterinarian								
	Supplementary examination in the DEC								
1	Evaluation and classification of carcasses in the DEC (40 sec/ carcass - 18.5% deviation - 1.1% lymphadenitis)		40.0	82		44.0	82		0.3
2	Sanitary management of slaughter procedures								
	Minimum number of high-school graduate staff - Official service								0.8
	Minimum number of high-school graduate staff - Company								2.2

¹ Out of tolerance for variability, 10% was added to the task-performance times.

UPHh: number of Units Produced per operator per Hour.

WF: necessary workforce.

Evaluating the results given above, it can be observed that the need for personnel is proportional to the line speeds, and occasionally more than one individual is needed for the performance of a single task. At slower speeds, and preserving the applicable good practices, it is possible by reorganizing the work on the lines, to have more than one task executed by one employee.

The time study, if extended to cover other inspection activities and also take time-off-work into consideration, may be used in order to stipulate the official workforce needed in slaughter establishments. Although the auditor's focus must continue to be on the correct execution by the classifiers of the tasks, the time study is an auditable method for establishing sufficient numbers of staff to perform the evaluation and classification activities.

Final remarks

Because the Mission of the Federal Inspection Service is to oversee the slaughter of swine and protect consumers against possible meat-borne hazards, the Service must keep abreast of changes in the raising system and adjust to address the new challenges facing consumers.

The specific circumstances of Brazil's system were studied for four years, surveys were carried out, data were gathered, international literature was consulted and (both in terms of methodologies and priorities) international agencies were aligned with. The proposal was prepared and discussed intensely among SIF representatives, Dipoa personnel and the researchers; finally, in challenging circumstances, it was validated in regions of Brazil with several different types of productive arrangements.

An economic analysis of the repercussions of the proposal is under way: initially it began with a detailed study of the establishments that were validated; at a later stage, the study will be extended to a range of hog-raising settings throughout Brazil.

With a view to advancing the Service, we recommend the modernization of the SIGSIF system, so as to incorporate the improvements detected during this project, which have been discussed by Dipoa personnel.

We highlight the pathogens that have been identified in this study as being able to impact consumers, but which are not perceived during ante-mortem and post-mortem sanitary inspection. We recommend that risk-attribution studies be carried out in order to understand if pork coming from industrial hog-raising activities is responsible, in Brazil, for the transmission to humans of *Toxoplasma gondii* and hepatitis E virus. We recommend also that biosecurity actions at hog-raising establishment-level be taken to control *Toxoplasma gondii*. In the case of hepatitis E virus, we recommend further investigations into the presence of the infectious virus in the raw material for feeds and ways of inactivating it in farm processes and controls.

We also propose that studies be carried out into process improvements, associating technological adjuvants to the treatment of products having a higher microbiological risk, which are sold fresh.

The production segment of the pork industry, which responds to global market demand for animal protein, depends on the safety of its products and the health of its herds for the maintenance and expansion. Changes are therefore also expected in regard to the hazards associated with hog-raising products. Improvements in production will likely eliminate some known pathogens and other hazards may take center stage. Given this dynamic, we recommend a new evaluation of risks related to the consumption of pork and pork products every ten years, in order to guarantee consumers' health and make Brazilian pork less vulnerable.

Finally, the project team would like to deeply thank all the professionals who have been involved in executing each phase of the project; we likewise acknowledge the financial aid of Embrapa and DAS/Mapa.

The final result of the task has culminated in the following risk communication:

MODERNIZATION OF SANITARY INSPECTION IN SWINE SLAUGHTERHOUSES

Risk-based inspection

As hog-raising has become increasingly technology-intensive, incorporating sanitary measures based on hygiene and biosecurity, the (zoonotic) risk profile associated with pork has changed. Cysticercosis and tuberculosis lesions were those most frequently detected by the inspection service in the past. Over time, these lesions ceased to occur, as a result of the improvements in the raising system and in sanitary controls applied to the production chain. Today, few foodborne illnesses are capable of being identified by direct inspection of carcasses: the greatest risk is that of contamination of the meat by microorganisms that have to be detected by laboratory tests. The current inspection regulation includes procedures to control hazards whose occurrence has fallen drastically with the technological progress of the production chain. It is thus clear that there is a need for modernization in order to adjust the focus of government actions to prevent hazards that pose a risk to food safety.

The project entitled “Review and modernization of ante-mortem and post-mortem inspection procedures applied in federally-inspected swine slaughterhouses” uses the risk analysis concepts recommended by international agencies for government decision-making. The Ministry of Agriculture’s Department of Inspection of Animal Products (Dipoa-Mapa) plays the role of Risk Manager, while Embrapa Swine & Poultry is the risk-assessment coordinator. The team of analysts includes university experts selected by Embrapa. The scope of the project covers Federal Inspection Service (SIF)-registered establishments, and accounts for 86% of Brazil’s hog slaughter. The animals slaughtered in these establishments come from intensive, technology-intensive production systems that are supervised by veterinary control.

The results of the project show that most of the rejections recorded by SIF are due to the detection of handling-, transportation- and slaughter-related lesions and defects. The risk assessment identified and characterized 23 biological hazards linked to the consumption of pork. The main hazard, with the highest level of risk, indicated by the risk prioritization, was *Salmonella*, the most-frequently found pathogen on swine carcasses. The other hazards were characterized as being low and very-low risk: only those hazards without an identification of risk were deemed negligible by the study. The control of cer-

tain hazards not amenable to visual detection on the slaughter line, as is the case for toxoplasmosis and hepatitis E virus, depends mainly on farm-level actions. Even so, there is a need to boost the understanding of the sources of infection in humans so that the official service can list its priorities, as well as the most appropriate links in the production chain where control and monitoring, if needed, can be applied.

Brazilian data gathered by SIF (2012 to 2014) recorded 14.3 rejections per million swine slaughtered, owing to parasitoses that can impact consumers (cysticercosis and sarcosporidiosis). This is borne out by a prospective study conducted in 2017, covering all SIF-registered establishments, in which no lesions compatible with cysticercosis were confirmed by laboratory testing. The same study confirmed that sarcosporidiosis lesions identified by the SIF are limited to breeder boars. These results indicate that inspection procedures that incise the head and tongue musculature ought to be maintained only for the slaughter of breeders, and eliminated for finisher hogs - which account for 99.2% of hogs slaughtered in Brazil.

Granulomatous lymphadenitis lesions accounted for 0.8% of the total number of carcass and viscera condemnations. This lesion is mainly caused by *Mycobacterium* (*M.*) of the *Avium* complex, classified as a low-risk hazard. Other mycobacteria such as *M. tuberculosis* complex, which occurs only occasionally, and is classified as being very-low risk, cause lesions that are indistinguishable at inspection. Since the detection of lymphadenitis is based on visual examination and the incision of several lymph nodes, and the site of the most frequent findings is the intestines, this procedure alone should be maintained under official control on the inspection lines. These lesions occur, secondly, in the lymph nodes of the head, which is removed intact from the line, and undergoes dressing. Head meat is used in cooked products. This disposition of head meat should prevent cross-contamination and eliminate possible microorganisms present in the oral cavity, including *Salmonella*. The head should additionally be treated in order to mitigate pathogens.

Fecal contamination was the second cause of the condemnation of hog carcasses in Brazil. Since feces may carry several hazards that have been prioritized in the risk assessment, a self-control plan was prepared with the objective of preventing carcass contamination by *Salmonella* and enterobacteriaceae. This procedure is based on the process control brought in by

Normative Instruction no. 60, dated 20/12/2018, within the scope of the pathogen reduction program.

The project concludes that the risk of foodborne infections from the consumption of pork in Brazil is low, and that changes in the inspection procedure may be carried out without jeopardizing consumers' health. The ante-mortem examination must be performed by the official veterinarian in order to identify and segregate animals that need greater post-mortem attention and to ensure the execution of official sanitary surveillance programs for diseases such as foot and mouth disease and swine fever. At the post-mortem inspection, some examinations of the viscera and carcasses may be totally excluded. Failures in the process may be detected and addressed by examination by the company's own responsible veterinarian, under official verification. The Official Service will retain the mesenteric lymph node examination under its own tutelage: other exclusive responsibilities will be the Final Inspection Department and verifications of the company's procedures and decisions, and of animal welfare indicators. Furthermore, the scope of the Official Veterinarian's activities is to maintain verification of hygiene processes, official sampling, and the adoption of product-related and process-related enforcement actions. The proposed changes to procedures are based on international scientific understanding and have been compared with the results generated in Brazil after a validation step, economic analysis and the capacity-building of those involved.

Regulations backed up by the results of the project, increasing the focus of public health-related inspection activities, will greatly contribute to ensuring the safety of Brazilian pork products.

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