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A COMPARATIVE STUDY OF VISUAL AND TRADITIONAL POST-MORTEM INSPECTION OF SLAUGHTER PIGS: ESTIMATION OF SENSITIVITY, SPECIFICITY AND DIFFERENCES IN NON-DETECTION RATES

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Une étude de 183.383 carcasses porcines a été faite dans un abattoir danois pour comparer la détection des lésions par une procédure d'inspection visuelle et par la traditionnelle inspection des viandes post-mortem. Le but de cette étude était de déterminer si la méthode visuelle pourrait être recommandée comme procédure officielle d'inspection des porcs charcutiers dans l'industrie de la viande porcine en Europe. La recommandation serait tributaire du maintien du niveau actuel de sécurité de la viande porcine et, par conséquent, sur l'absence de différence (ou une faible) entre les taux de non détection des deux méthodes, et donc la sensibilité et la spécificité de détection des lésions. La procédure d'inspection visuelle donne une bonne concordance avec les méthodes d'inspection traditionnelle pour la plupart des lésions ; la différence des taux de non détection était faible : environ une découverte supplémentaire pour 1.000 carcasses passées par inspection visuelle pour plus de la moitié (34/58) des lésions spécifiques considérées. Cependant, la procédure d'inspection visuelle entraîne un score significativement plus faible d'enregistrements que la méthode traditionnelle pour certaines lésions, par exemple la contamination fécale ou par la bile qui étaient manquées respectivement sur 8,7 et 2 cas pour 1.000 carcasses. La différence des taux de non détection pour certains abcès dépassait 2 p. mille. La spécificité des deux procédures était très élevée, mais la sensibilité modérée, plus basse en général pour la procédure d'inspection visuelle que pour l'autre, dans un échantillon choisi de conditions.
Nous concluons que les procédures d'inspection des viandes pourraient être réduites à des procédures d'inspection visuelle, sans risque pour la détection de la plupart des lésions. Cependant, l'abandon complet des méthodes traditionnelles d'inspection nécessite une analyse de risque de la sécurité alimentaire et de la santé humaine, associée à la plus faible capacité de l'inspection visuelle à détecter certaines lésions, notamment la contamination et les abcès. Ces recherches seront publiées comme suivi de la présente étude.

Traditional meat inspection procedures, based on slaughterhouse hygiene, ante-mortem, and post-mortem examinations, were initiated in the second half of the 19th century to protect the public from foodborne diseases. The diseases of primary interest such as tuberculosis, brucellosis, and abscesses are now of low prevalence because of improvements in veterinary treatment, control and prevention. In contrast, new concerns for food safety and quality have arisen since the implementation of the existing inspection procedures. Potential contamination of meat by residues and microorganisms (f. ex. *Salmonella*, *Yersinia*, *Campylobacter* species and *E. coli* O157:H7) causes greater consumer concern than the above-mentioned diseases. Furthermore, improved growth rates have led to earlier slaughter ages and a change in age-related diseases (Mousing 1988, Berends et al. 1993). Meat hygienists have thus suggested a need for new procedures (eg. Berends et al. 1993). Thus it is necessary to test and document whether inspection procedures might safely be simplified so that labor can be reallocated to detection of microbial contamination and xenobiotic residues.
The purpose of this study was to investigate if changes in the post-mortem inspection procedures of slaughter pigs to visual inspection only, would affect lesion detection in general, and whether detection of particular lesions relevant to public health and food safety would be substantially impaired. Two different numerical approaches were used in estimating the magnitude of differences in efficiency between the traditional and the visual inspection procedures.

MATERIALS AND METHODS

The study was conducted at a volunteering slaughterhouse (Danish Crown, Horsens). The study comprised comparative inspection of 211,008 slaughter pigs that arrived for slaughter at the slaughterhouse between February and July 1993 (excluding a period of labor strike from April 22, 1993 to May 16, 1993). The first procedure (VMI) was based solely on visual post-mortem inspection of carcasses and organs, while the second procedure (TMI) consisted of the traditional inspection procedures. One of the two commercial slaughter lines of the slaughterhouse was modified and expanded to enable a visual inspection of the carcass, plucks (heart, lungs, liver, tongue, trachea, oesophagus, diaphragm and kidneys) and gutset (gastrointestinal organs) before the traditional inspection. A mirror was installed to enable the meat inspectors to view the back, head and sides of the carcass without manual rotation. Plucks and gutsets were inspected with minimum handling or moving of

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the organs, as they passed by on conveyors. Only the outer surface of the organs and internal and external surfaces of the carcass were visually inspected. A number of inspectors were hired on to the plant to enable the extended procedures, but they were allocated to the lines and to the inspection platforms as an integral part of the total work force, so that there was no systematic difference between the lines and platforms in terms of the assignment of the inspectors.

Individual carcasses were identified by the rail numbers from which they hung and the time and date of slaughter. As inspectors completed their inspections, they entered the inspection results on finger-touch sensitive terminals, located at the inspection platforms. A maximum of 10 lesions could be assigned to each carcass. Computer software designated findings of the inspection outcomes to one of three data categories, depending on whether the findings were recorded at either of the two inspection platforms, or if recorded at both the VMI and the TMI stations. As a result, each lesion was identified by one of three mutually exclusive codes: M1, M2 or M3. Data files were transferred to a database manager (Paradox®) and a spreadsheet (Excel®) for analysis.

Agreement between the test procedures was evaluated by the approximate differences in non-detection rates (ADNDR) for VMI compared with TMI (Willeberg et al. 1994). Furthermore, sensitivities and specificities of both inspection methods were estimated by maximum likelihood-estimation as proposed by Hui & Walter (1980) and Walter & Irwig (1988), and as also discussed here, eg. by Chriel & Willeberg (1997). The method requires that two or more sub-populations may be identified as strata each of which yielding for each lesion code independent 2x2 tables of number of carcasses with the code as M1, M2, M3 or neither in each cell, respectively. Here 3 strata could be identified by the health status of the delivering herd (conventional, SPF or MS). BMDP and SAS procedures were used in the estimation procedures, which also included estimation of correlation of errors of the two diagnostic procedures (Donald et al. 1994) and statistical tests for model fit.

RESULTS

After data quality checks 183,383 records representing 126 different lesions/findings remained for statistical analysis. Here a restricted the number of codes will be shown for illustrative purposes (Table I). For 24 of 58 lesions with an observed frequency of 10 or more, VMI missed more than 1 lesion per 1,000 carcasses in excess of those missed by TMI. Among those were atrophic rhinitis, chronic pneumonia, old fractures and pericarditis. ADNDR exceeded 10 per 1,000 carcasses only for chronic pleuritis, catarrhal pneumonia and "milky spots" of the liver. Perhaps the most important differences for food safety and quality were those in detecting abscesses and contamination. The net ADNDR for detecting all categories of abscesses was 11.7 per 1,000 carcasses in favor of the TMI. The ADNDR exceeded 2.0 for abscesses of the neck and thorax, abdomen, and hindquarters, repectively. The TMI procedure was superior to the VMI method by an ADNDR of 8.7 for detecting faecal contamination and 2.0 for bile contamination. The ADNDR indicated that the VMI procedure was superior for six disease codes and findings. These include scabies, abscesses of the lung, abnormal odor, contusion, filled stomachs and aspiration of scalding water.

Table I
Frequency of selected lesions from visual (VMI) and traditional (TMI) inspection of 183,383 slaughter pigs

Lesion code	Meat inspection diagnosis	No.of pigs VMI-;TMI- (M0)	No.of pigs VMI+;TMI- (M1)	No. of pigs VMI-;TMI+ (M2)	No. of pigs VMI+;TMI+ (M3)	ADNDR[1] per 1,000 pigs
222	Chronic pericarditis	171,210	1,872	2,840	7,461	5.5
15	Chronic parietal pleuritis	141,052	5,853	12,988	23,490	44
282	Chronic visceral pleuritis	153,082	8,209	13,788	8,304	32
285	Catarrhal pneumonia	174,714	2,423	5,103	1,143	15
382	Milky spots in liver	172,171	2,552	5,458	3,202	16
931	Faecal contamination	177,647	1,448	3,032	1,256	8.7
941	Bile contamination	178,655	937	1,299	2,492	2.0

[1] Approximate difference in non-detection rate per 1,000 pigs: ADNDR=((M2 / (M2+M0)) - (M1/ (M1+M0)) * 1,000

The estimated specificities were all very high for both procedures as would be expected (Table II). Sensitivities varied, but were in most but not all lesions higher in TMI than in VMI. However, both procedures were moderate in absolute terms of sensitivity. There was a good agreement between the observed data and the MLE model predictions except for two of the 7 lesions in Table 2.

Table II
Sensitivities and specificities estimated by MLE from stratified[1] analysis of 183,383 slaughter pigs

Lesion code	Meat inspection diagnosis	Sens. VMI	Sens. TMI	Spec. VMI	Spec. TMI	Model fit[2] (p-value)
222	Chronic pericarditis	.80	80	1.0	.99	.72
15	Chronic parietal pleuritis	.66	.80	1.0	1.0	.58
282	Chronic visceral pleuritis	.42	.50	1.0	.99	.005
285	Catarrhal pneumonia	.22	.40	1.0	.99	.09
382	Milky spots in liver	.34	.53	1.0	1.0	.01
931	Faecal contamination	.32	.45	1.0	1.0	.47
941	Bile contamination	.91	.86	1.0	.99	.58

[1] Stratified according to herd health status, ie. conventional, SPF and MS (data not shown)
[2] Pearson chi-square from model with 2 d.f. and 7 parameters estimated, ie. the 4 test terms plus 3 prevalences

DISCUSSION

Generally there was a fair agreement between the visual and the traditional meat inspection methods, with some notable exceptions. Thus, visual inspection procedures were adequate to detect many specific lesions, some of which could be associated with potential consumer risks. Similar results were found by Habers et al. (1992). However, when abscesses and contamination are considered, the visual method might present potential quality problems and risks to consumers. The ADNDRs for fecal and and bile contamination of carcasses are of particular interest. Fecal contamination is a potentially serious risk, because enteric pathogens are major causative agents of disease transmitted through meat consumption. Likewise, bile can serve as a vehicle to carry Salmonella from the gall bladder to the meat. To further evaluate whether these potential draw-backs of the visual procedure are a real or merely a theoretical issue, a follow-up study, including microbiological risk assessment of the lesions in question, will be reported elsewhere (Mousing et al., in press).

There could be many reasons for the elevated non-detection rates for contamination of the visual method. In this study, the inspectors did not incise or palpate the tissues during the visual inspection. We suspect that part of the non-detection rate was attributable to the inspector's rather passive and monotomous monitoring routine, which may lead to underrecording of lesions.

Tests are best compared by analyzing their respective sensitivities and specificities. The ideal method is to compare the test findings to the findings from a "definitive» or "gold standard» method that is error free. For this study, we did not define a true gold standard. Instead, the objective of the study was to establish whether a simplified visual inspection procedure would be adequate to protect the consumer of pig meat, applying tissue inspection (not microbiological or residue detection), compared with traditional inspection. In this study we recognized that the traditional inspection, although not a "gold standard", serves as the current regulatory and legal standard. However, estimation of sensitivities and specificities of both the traditional and the visual inspection procedures were achieved by maximum likelihood estimation. These results also suggest that VMI is somewhat less sensitive than TMI for most lesions, but furthermore they underline, that neither the traditional procedure is consistently sensitive. The choice between VMI and TMI should therefore not be based on absolute numerical quality, but rather on cost-benefit and consumer risk evaluations of specific public health hazards (Mousing et al., in press).

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