Food Control 89 (2018) 177–186

Contents lists available at ScienceDirect

Food Control

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

Designing an innovative warning system to support risk-based meat inspection in poultry slaughterhouses

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ARTICLE INFO

Article history:
Received 8 December 2017
Received in revised form
25 January 2018
Accepted 2 February 2018
Available online 8 February 2018

Keywords:
Risk-based meat inspection
Warning system
Slaughterhouse
Poultry
Food safety

ABSTRACT

Historically and legally, meat inspection at slaughterhouses aims to ensure public health. Considering the sanitary, technical and regulatory developments, and given the growing societal concerns regarding animal welfare meat inspection has to be rethought based on a risk analysis to reach this objective. In this paper, we propose an innovative risk-based approach for poultry meat inspection based on a two-level warning system.

In order to meet the objectives of health inspections of animals and animal products, four inspection tasks in slaughterhouses were identified: (1) analysis of Food Chain Information, (2) *ante mortem* examination, (3) *post mortem* examination and (4) feedback information. For each health inspection task, a set of food safety, animal health and welfare criteria and warning values were determined on the basis of the opinion of a multidisciplinary expert group and regulations. In this system, observers (OBSs) are responsible for implementing the first level of control by checking all the criteria previously determined. In the event of a warning value for a criterion during the examination, OBSs must alert the experts (EXPs), triggering a request for an expert opinion. After receiving an alert, veterinary health and meat safety EXPs intervene at the second level by taking over the batch and implementing appropriate measures depending on the type of warning criterion involved. The respective skills and missions of OBSs and EXPs have been defined to each verification level by dividing up tasks, duration and actions. To ensure the implementation and traceability of the two-level control system, the values observed for each criterion and actions undertaken by OBSs and EXPs have to be recorded for all batches, either paper-based and/or computer-based. To ensure harmonised procedures, the OBSs must undergo national training sessions on *ante* and *post mortem* examinations. In addition, to maintain and improve the quality of this first level of the verification process, EXPs may carry out random checks to verify that OBSs are correctly verifying all stages of the slaughter process and correctly detect warning criteria. In case of abnormality, EXPs may send a non-conformity sheet and request corrective measures.

This study presents the first warning system applied to meat inspection in poultry slaughterhouses. Our comprehensive work was carried out with the support of a multidisciplinary group of experts, making it possible to formalise an efficient warning system. The next step has been to test this warning system in field conditions, on a sample of French slaughterhouses.

1. Introduction

Risk-based inspection is a concept that has been steadily gaining ground these last few years both in scientific and regulatory domains. Indeed, it has been demonstrated that mobilising resources to target high-risk sub-populations improves the sensitivity and cost-effectiveness of control systems (Lupo et al., 2009; Stärk et al., 2006). The scope of risk-oriented meat inspection is large and still

Abbreviations: FCI, Food Chain Information; OBS, Observer; EXP, Expert; AME, Ante Mortem examination; PME, Post Mortem examination; APT, action on the product; APS, action on the process.

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https://doi.org/10.1016/j.foodcont.2018.02.003

evolving: it may include the analysis of Food Chain Information to determine the flock's risk level and consequently adapt the inspection; the adjustment of inspection pressure depending on the plant's hygiene level or the type of flock to be slaughtered; or the implementation of targeted tests to detect the riskiest hazards following risk analysis (Anonymous, 2004b; EFSA, 2012). Its relevance for guaranteeing meat safety and monitoring animal health and welfare has been scientifically proven in all cases (EFSA, 2012; FAO, 2008). Compared to other animal species, the meat inspection of poultry is particularly tricky for several reasons. First, if performed in crates at the flock's arrival, the *ante mortem* examination is usually carried out on a sample of birds from high-density animal groups, making it difficult to detect clinical signs. If conducted at the hanging station before bleeding, the poor light conditions combined with the discrete clinical signs of most poultry diseases reduce the sensitivity of *ante mortem* examinations. Moreover, due to the high speed of the slaughter line, ranging up to 10,000 broilers per hour, the *post mortem* examination time for a single observer is usually limited to 0.4 s per carcass. The slaughter line's automation could also complicate inspection, especially regarding viscera, for which the connection to the correct carcass may be difficult. Finally, the hazards that are the most frequently linked to foodborne diseases related to the consumption of poultry meat are bacteria such as Campylobacter or Salmonella, that do not cause any clinical or lesional signs in animals (EFSA, 2012). Thus, they cannot be detected solely by the visual examination of animals and carcasses. Considering the specificities of poultry slaughter and the difficulties of poultry meat inspection, risk-based meat inspection approaches appear particularly relevant when seeking to improve poultry inspection sensitivity.

Poultry health inspection requires two distinct but complementary abilities: first, the ability to detect something abnormal or unusual and characterise the risk; then, to manage the risk linked to this abnormality and avoid its reoccurrence. The first step is linked to field-level skills, whereas the second one needs veterinary expertise. Poultry health inspection could therefore be performed in a cooperative way by two different professional groups depending on their qualifications. Such a shared control system has to be well-structured to make the information transfer between the two control levels reliable and efficient. Warning systems implemented in other fields related to health or surveillance have been designed to detect events with a potential health risk and to respond appropriately to the event, both detection and response stages being well-articulated. In France for example, alert systems in human health have been defined as epidemiological surveillance systems aiming to detect as soon as possible any unusual health event presenting a potential risk for public health (InVS, 2005). With a view to ensuring operational efficiency, alerts should be detectable at several levels and by several stakeholders or indicators to increase their probability of detection. Therefore, alerts usually come from two types of source: the monitoring of routinely collected health indicators (e.g. when a threshold for pollutant concentration is exceeded), and/or the monitoring of events associated with a threat to public health (e.g. unusual clinical signs of a hospitalised patient). An alert must subsequently be confirmed through signal verification, then characterised and evaluated. Once the alert has been confirmed and evaluated, it has to be managed through several steps: (i) notification and dissemination of the alert to the competent authorities and all stakeholders; (ii) diagnostics to find the source and cause of the hazard and to treat it; (iii) end of the alert with the evaluation of the measures implemented and feedback to all stakeholders. All these steps have to be recorded, since traceability is a key aspect of alert management. This kind of alert scheme has to be determined before an alert, and geared to the sector of activity. Similarly, in other fields of work, Leonard, et al. (2008) highlighted five steps guaranteeing the efficacy of alert systems: (i) the system has to enable early detection and information; (ii) it has to be planned; (iii) means of discussion and communication have to be developed to ensure stakeholders' cooperation; (iv) stakeholders have to be trained and sensitised; (v) table-top exercises have to be performed.

Following the example of several efficient alert systems in various health fields, the aim of our work is to propose an innovative risk-based approach to poultry meat inspection based on a warning system. This entailed first defining the missions and tasks involved in meat inspection and then proposing a global and integrated organisation of inspection all along the production chain.

2. Identifying the aims of health inspection at poultry slaughterhouses

Historically (Dumas, Koeahle, Chal, & Bornert, 2010) and legally (Anonymous, 2004b, 2005; FAO/OMS, 2002; OIE, 2017) meat inspection at slaughterhouses aims to ensure public health. Considering the sanitary, technical and regulatory developments (Anonymous, 2004b, 2007, 2008), and given the growing societal concerns regarding animal welfare, meat inspection has to be rethought. The main objectives of health inspections of animals and animal products were defined as follows: (1) ensuring food safety (detection of hazardous food and food spoilage), (2) monitoring animal diseases and (3) monitoring problems about rearing, transport and lairage facilities, which may affect animal welfare.

Before designing the warning system, a preliminary task involved collecting comprehensive data on health inspections. Firstly, information about the detection of sanitary issues having an impact on public health was gathered. This involved reviewing regulations using keywords such as zoonosis, animal health, animal diseases, animal welfare, and consumer safety. Secondly, all the actions taken at slaughterhouse level to manage sanitary problems and provide feedback to primary production were investigated. This preliminary work was conducted in collaboration with a multidisciplinary group of experts composed of scientists, official services based at slaughterhouse, public authorities and food business operators. Finally, the information collected was summarised so as to structure and clearly define meat inspection, as presented below.

3. Determining health inspection tasks

In order to meet these three objectives, four inspection tasks in slaughterhouses were identified (Fig. 1) in accordance with general regulatory requirements (Anonymous, 2004a, 2004b). These steps occur in a well-defined chronological order, and the outcome of each step has to be validated before continuing to the next step.

3.1. Task 1: Analysis of Food Chain Information (FCI)

The first verification is at farm level. It is designed to ensure that animals entering the slaughterhouse comply with the legal hygiene requirements for human consumption. This documentary step, which takes place at the slaughterhouse, is based on the checking and analysis of Food Chain Information (FCI) providing relevant information on livestock during the rearing period. It must be carried out before the collection and transport of animals and early enough to decide, if necessary, to postpone the slaughter (with livestock remaining on the farm); to strengthen inspections at the slaughterhouse; and/or to reorganise the slaughter process (e.g. to change the order of batch slaughter, slow down the slaughter line, or enforce stricter cleaning). To comply with legislation, the FCI form must be sent to the slaughterhouse at least 24 h before

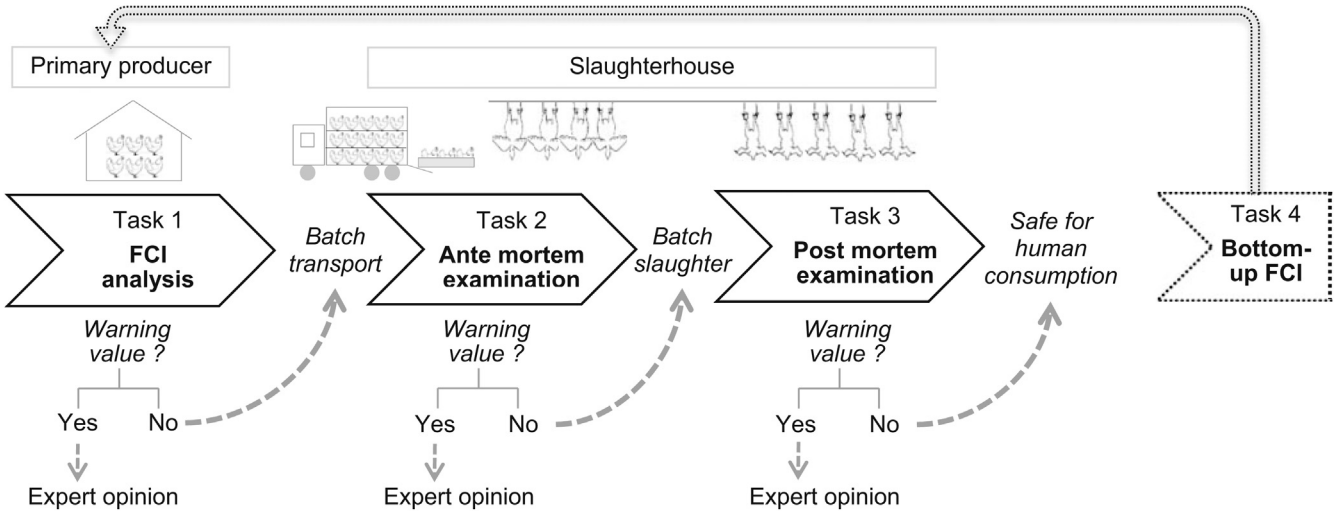

Fig. 1. Four health inspection tasks carried out on animals and animal products in poultry slaughterhouses.

slaughtering.

3.2. Task 2: Ante Mortem Examination (AME)

According to EU regulations (Anonymous, 2004b), the AME is either a visual examination of live animals at the source farm, combined with record checking and verification of farm documentation, including FCI; or a visual examination of birds on the batch's arrival for slaughter. The second proposal was chosen because this method is already implemented in France, as indeed in most EU member states. The aims of AME are to check the animal's identification and to detect clinical signs related to a disease or noncompliance with animal welfare requirements (Alban, Steenberg, Stephensen, Olsen, & Petersen, 2011; EFSA, 2012). Firstly, the batch's identification is checked by comparing the characteristics of animals sent to the slaughterhouse with data in the FCI. Secondly, the examination of animals in crates (after unloading or stunning) makes it possible to remove any dead animals, animals that look ill or animals whose health status might affect consumer health. In the poultry sector, the detection of abnormalities linked to a noncompliance with animal welfare regulations (on the farm or during transport) has recently been added to AME objectives (Anonymous, 2004b).

3.3. Task 3: Post Mortem Examination (PME)

The PME consists of a macroscopic examination of all carcasses and accompanying offal. It aims to identify abnormalities or hazards having an impact on the environment, human or animal health and/or which make the meat unfit for human consumption (EFSA, 2012). The list of abnormalities to be detected must be clearly defined and established, and has to consider slaughter conditions, the feasibility of observations and the detection at inspection points. The detection of such an abnormality necessarily leads to condemnation of the carcass, part of the carcass, and/or the viscera and subsequent management of the meat and by-products.

3.4. Task 4: Feedback information

After slaughter, feedback on the livestock's welfare and health performances has to be given to the primary producer and/or to official farm inspection services.

4. Setting verification criteria and their warning value

For each health inspection task, a set of criteria and associated warning values for were determined on the basis of the multidisciplinary group's expert opinion and regulations (Regulations (EC) No 853/2004 and 854/2004). These criteria, related to animal identification, animal health, public health and/or welfare, were selected for their measurability and feasibility in field conditions at the slaughterhouse (Anonymous, 2012a, 2012b; Lupo et al., 2009). The definition and method of calculation were clearly stated for each criterion so as to standardise and harmonise the evaluation.

Overall, 22 criteria were selected: ten, eight and four criteria for each of the first three tasks respectively. Of these, ten were qualitative and 12 quantitative. The alert thresholds for the quantitative criteria were based either on regulations or expert opinions (Table 1). Thresholds relative to mortality rates and condemnation rates were set on the basis of expert opinions, and varied with species and type of production. All the criteria are described below for each verification task.

4.1. Criteria for task 1, "FCI analysis"

The relevant information to be provided on the FCI form is general information regarding the identification of the batch and traceability of all major health events occurring during the rearing period. The set of criteria to be checked and evaluated was established as follows:

- absence of the FCI form 24 h before slaughter
- the farmer signed the FCI form more than 5 days before slaughter,
- an abnormality during AME and/or PME has been detected on a subsequent batch to be slaughtered from the same flock
- the withdrawal period for a veterinary medicinal product, a compound with a withdrawal time or medicated feed has not been filled in,
- information on mortality during the first 10 days of rearing (only for broiler chicken production), mortality during the last two weeks before slaughter and/or total mortality has not been provided,
- the results of tests to detect Salmonella have not been filled in (only for broiler chicken and turkey production),

Table 1
Health inspection objectives fulfilled by the verification criteria defined by task, criteria references (regulation or expert advice) and type of alert in the case of a criterion's warning value.

Task	Criteria	Health inspection mission			Criteria reference			Type of alert[b]
		Food safety	Monitoring of animal diseases	Monitoring of problems affecting animal welfare	European Regulation	National Regulation	Expert opinion	
task 1	expired or missing FCI form	■	■		■			AL
	abnormality during AME or PME detected on a subsequent batch	■	■	■	■			AL
	withdrawal period for a veterinary medicinal product/ medicated feeds	■			■			AL
	mortalities		■		■	threshold[a]		AL
	results of Salmonella analyses	■			■	■		AL
	misidentification of slaughterhouse				■	■		AL
	batch from a farm or an area subject to a ban on movement or other restriction	■	■		■			AL
task 2	simultaneous reception of the batch and the FCI, or reception of the batch without the FCI form	■	■		■			IM AL
	mismatch between the number of received animals and the number of animals indicated on the FCI form		■		■			AL
	mortality in crates during transport		■	■		threshold[a]		IM AL
	clinical symptoms	■	■		■			IM AL
	stocking density in transport			■	threshold			AL ES
	unusually dirty batch	■	■	■	■			AL ES
task 3	condemnation rate	■	■		■	threshold[a]		AL ES
	condemnation relating to an infectious phenomenon	■	■				threshold[a]	<10% AL ES >10% IM AL
	condemnation relating to a welfare problem	■		■			threshold[a]	AL ES
	unusual abnormalities	■	■			threshold[a]		AL

[a] Threshold based on the opinion of a multidisciplinary group of experts.
[b] Type of alert: Immediate alert the EXPs (IM AL), Alert the EXPs during verifications (AL), Alert the EXPs at the end of the slaughter day (AL ES).

- compliance with the withdrawal period for a veterinary medicinal product, a compound with a withdrawal time or medicated feed has not been proven,
- the results of Salmonella tests are positive,
- mortality during the first 10 days of rearing (only for broiler chicken production), mortality during the last two weeks before slaughter and/or total mortality are higher than the set threshold,
- the slaughterhouse of destination does not match the one identified on the FCI document,
- the batch comes from a farm or an area subject to a ban on movement or other restrictions for animal or public health purposes.

4.2. Criteria for task 2, "AME"

Upon the batch's arrival, the AME of animals before slaughter has to be based on the verification of the following criteria:

- reception of the batch without FCI documentation,
- simultaneous reception of the batch and the FCI,
- mismatch between the received batch and the FCI, i.e. the FCI document does not correspond to the actual situation of the source farm or conditions of the animals (e.g. an issue with the animals' identification),
- mismatch between the number of received animals and the number of animals mentioned on the FCI document,
- mortality in crates during transport is higher than the set threshold,
- birds showing clinical symptoms of a disease, such as shortness of breath or prostration, paralysis or others with nervous symptoms,
- noncompliance with rules concerning the storage density in transport crates,
- unusually dirty batch.

4.3. Criteria for task 3, "PME"

This verification requires the recording of all condemnations and the three main reasons for condemnation (in decreasing order of frequency). These results were used to define a method for calculating the condemnation rate. The latter can be calculated either in carcass weight or carcass number (Bremner, 1994; Cervantes, 1999; USDA, 2005, 2008). Following expert opinions and the observation of field practices, it was decided to harmonise calculation of the number of carcasses condemned in each batch slaughtered as described by Salines, Allain, Roul, Magras, and Le Bouquin (2017). Moreover, it is important to set a differentiated threshold for the condemnation rate according to the type of reason for condemnation (infectious phenomenon or welfare issue). Considering these technical measures, the following four criteria were chosen for task 3:

- condemnation rate higher than the set threshold,
- condemnation rate higher than the set threshold if the first main reason for condemnation corresponds to an infectious phenomenon (such as "generalised congestion" or "cachexia"),
- condemnation rate higher than the set threshold if the first main reason for condemnation is related to an animal welfare problem (such as "leg deformation" or "broken bone(s)"),
- batch for which the proportion of carcasses showing unusual abnormalities is greater than or equal to 0.5%.

5. Organising the warning system

The warning system is based on the principle of a two-way information flow: from observers (OBS) to experts (EXPs) and vice versa. The organisation of the warning system is detailed below.

5.1. Organisation of health inspection and alert communication

The respective skills and missions of OBSs and EXPs have already been clarified. For each task, the examining person has been defined. The timing of the implementation of tasks and actions to be taken in of the event of a warning value have also been described. The warning system has been designed as a two-level control system. OBSs are responsible for implementing the first level of control by checking all the criteria previously listed. In the event of a warning value for a criterion during the examination, OBSs must alert the EXP, triggering a request for an expert opinion. The time required for this expert assessment and implementation of corrective actions varies with the type of warning alert. A time period for alert transmission was therefore defined depending on the degree of urgency: immediate, during batch slaughter or at the end of the slaughter day (Table 1). After receiving an alert, veterinary health and meat safety EXPs intervene at the second level by taking over the batch. They have to implement appropriate measures depending on the type of warning criterion involved. These measures may include and extended documentary analysis, immediate action on either the whole batch or on one or more animals in the batch (live birds, carcasses or offal) and/or ex post corrective action such as an on-farm inspection (Table 2). The EXPs have to communicate inspection results and decisions concerning FCI, live animals, animal welfare and meat. More specifically, the two levels of the verification process are articulated as follows for each task:

Task 1: Before authorising animal transport to the slaughterhouse, OBSs have to check and analyse relevant information from the FCI documentation. Should there be no FCI form, or if one of the criteria has a warning value, an alert must be triggered and transmitted to the EXPs. Upon receipt of the alert, EXPs have to implement appropriate measures. Figs. 2 and 3, for instance, present the actions that have to be taken by OBSs and EXPs respectively if the FCI is not provided within the period of time allowed before slaughter.

Task 2: OBSs have to carry out an AME of animals before slaughter by checking the batch's identification and ensuring that animals are fit for slaughter. If a warning value is detected, OBSs have to alert the EXPs.

Task 3: At the *post mortem* examination, OBSs carry out a visual inspection of all carcasses. They have to detect any abnormality, which must result in the condemnation of the carcass, part of the carcass or the related offal, as well as in the appropriate management of the animal's by-products. OBSs have to count all condemnations. They must indicate the three major reasons for

Table 2
List of actions that may be carried out by the OBSs (n = 2) and the EXPs (n = 35).

Actor	Actions
OBS	Transmit alert to the EXP
	Send feedback to the primary producer
EXP	Check that the farmer is given the correct feedback
	Keep animals on the farm
	Postpone slaughter until further information is obtained
	Extend the documentary examination + keep livestock on the farm
	Extend documentary examination
	AP
	Extend the AME
	Extend the PME
	Extend the AME & PME
	Extend the AME & PME + APT
	Extend the AME & PME + AS
	Extend the AME & PME + APT + APS
	Extend the documentary examination + AME
	Extend the documentary examination + PME
	Extend the documentary examination + AME & PME
	Extend the documentary examination + PME + APT
	Extend the documentary examination + modify the order of batch slaughter
	Extend the documentary examination + modify the order of batch slaughter + extend the AME & PME
	Put the batch on hold + extend documentary examination + extend AME
	Put the batch on hold + extend documentary examination + extend AME & PME
	Put the batch on hold + extend documentary examination + extend AME & PME + AP
	Analyse PME results + give feedback to the farm inspection service
	Analyse PME results + ensure consistency with the main reasons of the condemnation
	Visually inspect all carcasses and all condemned carcasses/offal + extend documentary examination
	Visually inspect all carcasses and all condemnations + extend documentary examination + AP
	Visually inspect all carcasses and all condemnations + extend documentary examination + PME
	Slaughter at the end of normal slaughtering + extend verifications + detain the batch while awaiting further information
	Slaughter at the end of normal slaughtering + extend examination + detain the batch while awaiting further information + schedule a farm inspection
	Slaughter at the end of normal slaughtering + extend examination + detain the batch while awaiting further information + if no information within 48H = condemn the batch
	Slaughter at the end of normal slaughtering + extend examination + detain the batch while awaiting further information + if no information within 48H = condemn the batch + schedule a farm inspection
	Give feedback to the farm inspection service
	Schedule a farm inspection
	Deliver a non-conformity sheet to the OBSs if the alert was delivered too late or not at all
	Deliver a non-conformity sheet to the OBSs if no alert was transmitted + AP
	Deliver a non-conformity sheet to the OBSs if there was a detection failure

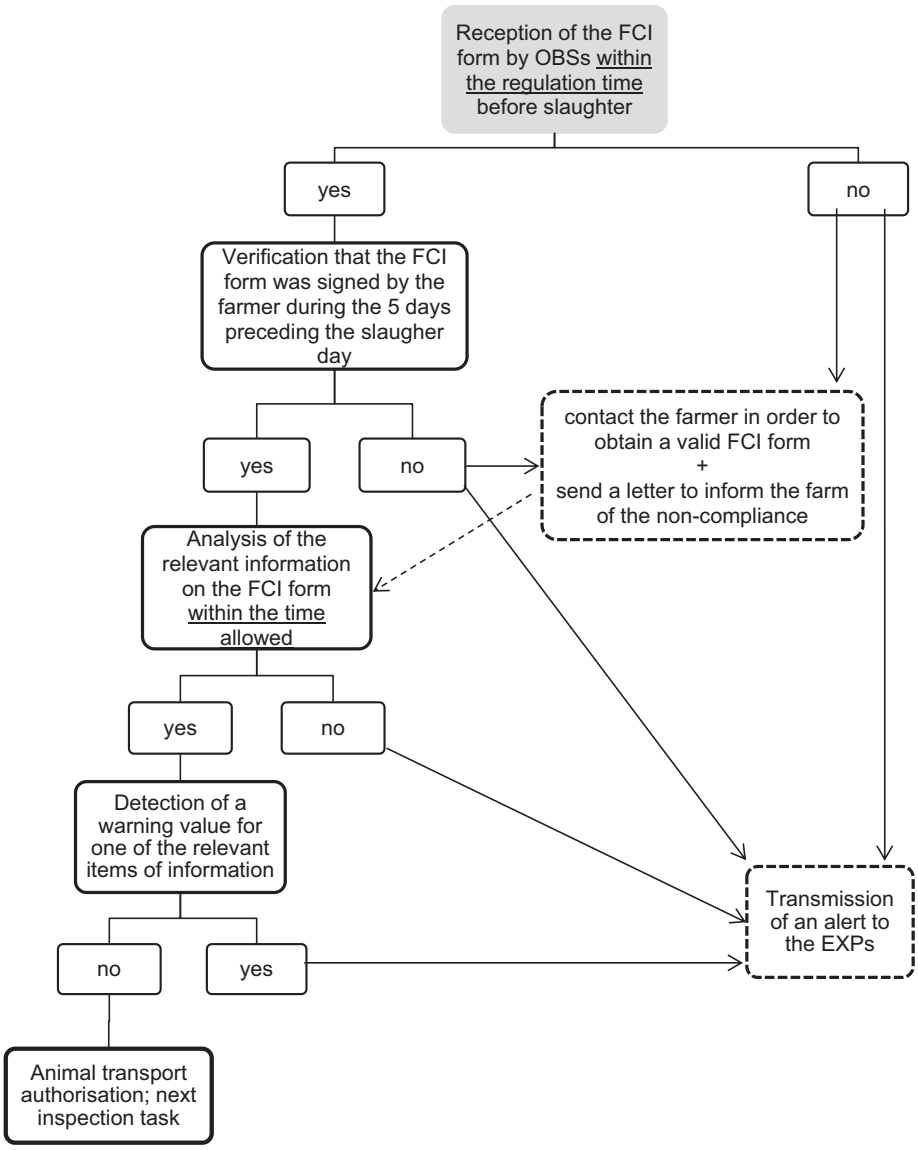

Fig. 2. Verifications —— and actions - - - taken by OBSs for task 1 "checking the FCI".

condemnation on a batch scale. If the condemnation rate is found to be higher than the threshold, OBSs should send an alert to EXPs.

Task 4: This task is based on the results of the three previous meat inspection tasks. It consists in sending feedback information to the farmer and/or to farm inspection services when certain warning criteria have been observed during the checking process. This results in the identification of batches at risk, for which information must be sent to the farmer by OBSs and/or to the official veterinarian monitoring animals on the farm of origin by EXPs. This enables a "bottom-up" information flow on health and welfare in order to improve animals' health status and the quality of raw meat products in the first stages of the production chain (Ansong-Danquah, 1987; Lupo et al., 2013). Task 4 also includes feedback between the two control levels. If the ex post verification shows that OBSs have not detected warning values or not detected them in time, EXPs send OBSs feedback in the form of a non-conformity sheet in order to improve the verification of abnormalities that have to be detected on a subsequent batch and that of warning criteria on the FCI document. Depending on the severity of the error, sanctions can be taken and updating and consolidation of knowledge and skills of OBS can be necessary.

5.2. Harmonisation and standardisation of practices and procedures

For all batches, the values observed for each criterion and actions undertaken by OBSs or EXPs have to be recorded in order to ensure the implementation and traceability of the two-level control system. Records can be either paper-based (e.g. FCI form and score sheets) or computer-based. The data recording protocol is established as follows:

Task 1: based on the FCI form proposed by EU regulations, a standardised FCI has been created for each species. It includes regulatory and administrative requirements together with information related to food safety and animal health and welfare. The FCI form contains specific information depending on the species and a common part which includes the batch traceability criteria required by the regulations and other criteria such as health history, medical treatment, technical characteristics, etc.) recognised as being useful for a risk-based approach (Fredriksson-Ahomaa, 2014;

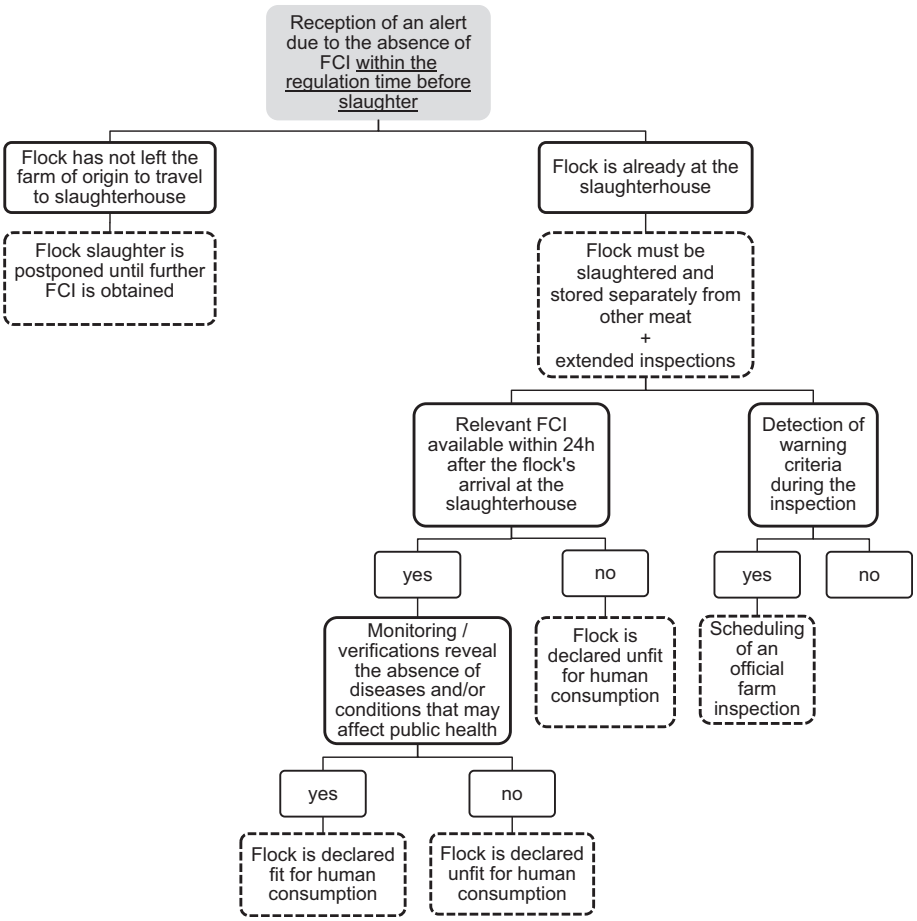

Fig. 3. Verifications ——, decisions and actions – – – taken by EXPs after receiving an alert due to absence of the FCI form within the period of time allowed before slaughter.

Huneau-Salaün et al., 2015; Lupo et al., 2013). As an example, Fig. 4 presents the FCI check carried out by OBSs in broiler production. For the verification task, OBSs screen all the criteria and point out directly on the FCI (by underlining or encircling) the identified warning criterion(a). This traceability enables an ex post verification to ensure that warning value of one or more criteria was or were correctly detected by the OBS.

Task 2: to mitigate the impact of OBS' personal judgment, AME has to be performed with scoring scales based on pictures. These scales were designed by each slaughterhouse because of the specific conditions related to species and production type, the slaughtering tool and observation conditions.

Task 3: similarly, national reference frameworks have been designed to harmonise the condemnation process by OBS. For each species, this document describes condemnation criteria, reasons for condemnation based on pictures and related legislation, and actions to be taken (De Turckheim, Le Bouquin, Donguy, & Magras, 2013; Salines et al., 2017) (available here: http://www.infoma.agriculture.gouv.fr/Referentiel-des-lesions-et-motifs). During the *post mortem* examination, OBSs have to classify condemned carcasses according to the reason for condemnation. This classification is then used to determine the three major reasons for condemnation, according to the pre-established list of lesions referred to by the national reference document.

For tasks 2 and 3, OBSs have to record the results of the *ante* and *post mortem* examinations in score-sheets. This paper registration ensures traceability and allows EXPs to carry out a documentary analysis during an extended inspection (consultation of FCI, score sheets, results of the *post mortem* examination,etc).

In addition to paper-based records, two standardised databases were created specifically and separately for OBSs and EXPs. These databases are used to record the identification data and information about the batches, the value of the criteria and all actions taken. To decrease the risk of response bias and data input error, drop-down menus are proposed when the response must be closed-ended and precise, and a user guide was written. More specifically, the multidisciplinary group of experts established an exhaustive list of actions to be undertaken in the event of an alert indicating the various options available (Table 2). This framework of actions avoids open answers, facilitating the registration of data and information processing. Two types of action are considered for OBSs in order to inform the farmer or/and to alert EXPs. Thirty-five actions are listed for EXPs in charge of the batch at risk. Figs. 2 and 3 present an example of actions undertaken by OBSs and EXPs respectively in the event of an alert.

Moreover, an automated data migration system was proposed whereby batch identification information recorded by OBSs is automatically transferred to the EXP database. This provides EXPs with all the information needed about the identification of slaughtered batches to record inspection activities.

Another automated data migration system was developed to transfer all the lines for which at least one of the criteria is on alert in a specific database. This database is used to fulfil Task 4 "feedback information" for example, relevant data being transferred from EXPs to the animal health department. Such a system would allow a standardised and automated bottom-up FCI approach.

FOOD CHAIN INFORMATION FORM: GALLUS

Name of the holding:	Tel:
Farmer's surname and first name:	Fax:
Address:	Number of the holding (EDE or SIRET):
Producer organisation or group:	
Address:	Tel: Fax:
Technician responsible for monitoring the holding:	Tel:
Veterinarian responsible for monitoring the holding:	Tel: Fax:

I. Flock characteristics

Number of the housing unit on the holding (INUAV):	Strain:	Source hatchery:
Address of the housing unit (indicate the town if different from the holding's town):		
Flock number:	Production type: ☐ standard ☐ certified ☐ Label Rouge ☐ Organic ☐ Other, specify :.....	
Number of birds at placement:	Placement date:	Age at placement:
If standard, certified or export production, specify the maximum stocking density (kg/m²): 33 ☐ 39☐ 42☐		

II. Feeding Program *(fill in all the rows or cross out the table if no compound with withdrawal time or medicated feed was distributed in the 30 days before slaughter)*

Feed company (if different from the producer organisation or group): ….....

Compound feed (with withdrawal time) or medicated feeding stuffs distributed in the 30 days before slaughter	Date of first distribution	Date of last distribution	Withdrawal time (days)	Prescribing veterinarian (if medicated feeding stuffs)

III. Production data and flock health status

Average live weight	Mortality: on the date of FCI form dispatch	Number	%
Average live weight 15 days before slaughter:	Total mortality		
Average live weight 8 days before slaughter:	Mortality in the first 10 days (standard, certified, light)		
Estimated average live weight at slaughter:	Mortality in the last 15 days		

Observations on the flock's health status and any comment on the mortalities:

Examinations for Salmonella: ☐ **yes** ☐ **no**	Laboratory: .....
Date of sampling: ...../...../..... Holding covered by a derogation : ☐ yes ☐ no (if no, the result of the sampled flock is valid for 3 weeks) Derogation - Regular removal : ☐ yes (result is valid for 8 weeks for the holding / for several flocks) Derogation - all-in/all-out production: ☐ yes (result is valid for 8 weeks for the holding or only one housing unit sampled)	**Test result:** ☐ **presence** ☐ **absence** **if presence, serotype :** ..... Positive carcass: ☐ yes ☐ no ☐ not examined

IV. Accidents, diseases, treatment administered by prescription *(cross out table if no accident/treatment)*

If tests are ongoing, or test results pending, please specify: .....Name of the Laboratory: .....

Diseases, accidents (in the last 30 days)	Treatment (registered trade or proprietary name)	Start date of administration	End date of administration	Withdrawal time (in days)	Prescription number

V. Removal to slaughterhouse

Multiple removals : ☐ yes ☐no			
	Slaughtering date 1: … / … / …..	Slaughtering date 2: … / … / …..	Slaughtering date 3: … / … / …..
Number of birds			

Farmer		**Name of slaughterhouse of destination**	
I certify on my honour having duly completed this document, and undertake, in the event of unplanned events that could modify its content after its dispatch, to alert the slaughterhouse according to the procedures defined.	Date and signature:	I certify that I have taken note of the information recorded on this document before slaughtering the batch, and that: ☐ I did not identify any warning criteria for this batch ☐ I identified one or more warning criteria for this flock, and am duly transferring this document to the official veterinary services, indicating the warning criterion(a) observed.	Date and time of validation: Signature:

Fig. 4. Model of a Food Chain Information (FCI) form for broiler chicken production.

5.3. Mandatory training and verification of correct implementation

In order to ensure harmonised procedures for the checking system and to meet regulatory requirements (Anonymous, 2004b), OBSs have to be regularly trained for *ante* and *post mortem* examinations. Two types of training courses have been designed nationally. Both include items regarding regulations on animal welfare, food safety and hygiene. The first training course aims to teach OBSs how to perform AME and to take corrective actions if necessary. The objective of the second training course is to give OBSs the ability to detect abnormalities resulting in the total or partial condemnation of carcasses and offal. The implementation of these training courses using reference documents limits the observation bias linked to the personal judgment of OBSs, which is known to affect the condemnation process (Lupo et al., 2008; St-Hilaire & Sears, 2003). Training is provided by accredited training centres and must be renewed every five years.

In addition, EXPs have to carry out random checks to verify that OBSs are correctly verifying all stages of the slaughter process. Such checks are essential in order to maintain and improve the quality of this first level of the verification process. In the same way, EXPs can carry out regular unannounced inspections along the slaughter line to ensure that all batches receive appropriate physical *ante* and *post mortem* examinations and that guidelines are being properly applied (De Turckheim et al., 2013; Gelin, 2013; Peroz, Allain, Donguy, Le Bouquin, & Magras, 2013). All these checks mitigate the risk of deviation in the verification of criteria, and consequently ensure the process's homogeneity. In the event of a problem, corrective actions have to be implemented to correct OBSs' mistakes and, if necessary, sanctions can be taken according to the severity of the non-compliance.

Lastly, EXPs can check the quantitative criteria ex post by recalculating the withdrawal period for a veterinary medicinal product or a medicated feed, the mortality rates during rearing, the validity deadline of Salmonella results, storage density in crates, the difference in percentage between the number of animals received and the number of animals provided on the FCI form, mortality in crates and condemnation rates. By doing so, EXPs verify that the criteria are well detected by OBSs. If not, EXPs have to send a non-conformity sheet to OBSs and requesting corrective measures.

6. Conclusions

Our study presents the first warning system applied to meat inspection in poultry slaughterhouses. Our comprehensive work was carried out with the support of a multidisciplinary group of experts, making it possible to formalise an efficient warning system. The objectives of health inspections, tasks, verification criteria and warning values relevant to meat safety and animal health and welfare have been defined. Checking operations and actions have been clearly divided between two professional groups having complementary skills for health inspection. Procedures and reference documents have been designed to ensure efficient coordination and communication between stakeholders. Such a risk-based inspection system would optimise meat inspection while guaranteeing food safety.

This warning system has been tested in field conditions. The results will be published in a next paper. Indeed, the experiment on a sample of slaughterhouses has allowed the system's efficacy to be tested in the field and reveal means of improvement. Implementing this harmonised, standardised system in all slaughterhouses would also allow the health status of the poultry sector as a whole to be monitored and would provide epidemiological data for input into other research projects in order to improve the quality of production.

Acknowledgements

The authors would like to thank the French Ministry of Agriculture and Food for funding this research, and the group of experts for their participation in the project.

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