Working Group 1 - Scope and targets of meat safety assurance

DELIVERABLE

PRELIMINARY REPORT ON SCOPE OF MEAT SAFETY ASSURANCE SYSTEM AND COMPETENCES AND ROLES OF RISK MANAGER

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Objectives of the WG1:

1. Mapping existing meat safety and quality assurance schemes;
2. Identification of the scopes/aims of the current and the future meat inspection and meat safety assurance system and the interface of public health with animal health and welfare assurance;
3. Identification of the roles and responsibilities within the current and the future risk based meat safety assurance system (all informed by outputs from WG2, WG3 and WG4);
4. Mapping the roles of the risk manager in the future meat safety assurance system;
5. Prioritisation of the hazards (risk-ranking, periodic re-ranking and regional rankings of hazards for public health and animal health and welfare) and investigation of approaches for setting risk-related targets in the meat chain.

This report addresses following WG1 Grant Period goals:

Grant Period 1

1. *To collect information for existing MSAS and conduct case study analysis (poultry, red meat) along their focus and impact along the production chain (the outcome should exemplify different approaches to MSAS and their different contexts);*
2. *To define what are the current MSAS and future MSAS objectives and deliverables in terms of food/meat safety, animal welfare, environmental protection, food/meat quality, ethical and sustainable food production, etc.;*
3. *To consider the competency profile or the future "risk manager".*

Grant Period 2

1. *To produce report on current MSAS including: a) to analyse options for integration of MSAS within official control; b) to outline to the extent possible the interface and developing and validating conceptual model for MSAS, and c) to outline future development and utilisation of the profile of risk manager (draft paper to be made out of the report);*
2. *To suggest practical tool/platform for prioritization of hazards.*

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1. Summary

Food safety require a farm to fork approach to be efficient. Among food meat represents a complex issue in that it requires several processing stages to reach the market, involving live animals. Animal health and animal welfare need to be considered within the chain with specific competencies. Another factor of complexity is due to the risks, arising mainly form farm, that need to be mitigated along the meat chain. The EU level MSAS need to consider all these characteristics framing them with appropriate legislation and allowing different food chain actors to act specifically, according to their role, with the common aim of delivering safe food to consumers. Starting from current tools, and considering a medium to long horizon it is possible to identify private scheme and food chain information as systems showing promising possibilities.

Private assurance scheme can offset the need for legal requirements and inspections and uptake of these schemes is higher where it is possible to use them to demonstrate compliance with regulation or inspection.

An assurance scheme that simply mimics the law is unlikely to be able to frame itself as providing much additional value to members. Similarly, if all MSAS were equal, they could not frame themselves as better than competitors. So, there is a need to identify the aspects in which different MSAS are equivalent to official controls, and it would be helpful also to learn if the equivalence is due to having equal requirements than official controls (process-based) or enabling equivalent results (outcome-based).

Food Chain Information represent a good starting point with space for improvement in terms of quality, quantity, effectiveness and ability to reach different actors across the production chain. FCI should exploit the potential of innovative IT technologies to pair traceability and safety data making them available to different private and public actors along the chain. Key components will be the two way exchange of information between the primary producer and FBO as well as the availability of information beyond slaughterhouses.

Keywords: meat inspection, meat safety assurance system (MSAS), vertical integration, food chain information

2. Introduction and context of the report

This report is developed in the frame of the RIBMINS (Risk based meat inspection and integrated meat safety assurance) project and will address questions of current risk-based meat safety assurance systems (MSAS) and future perspectives in defining the scope and targets of meat safety assurance system, having regard to the grant period goals of year 1 and 2. The focus of the report is the meat safety assurance systems (MSAS) from the farm until the cooled carcass currently in place.

It should be noted the global interest in the topic of development of risk-based meat inspection and meat safety assurance schemes. The FAO have issued technical guidance principles of risk-based meat inspection and their application (2019) and a guide to ranking food safety risks at the national level (2020). The novel legislation in the EU opens up more possibilities for sharing information and competitive evolution of meat safety assurance schemes. For example, the European Commission DG SANTE, (2017) has published a report on shard practices on slaughter hygiene.

2.1. Terms of reference and objectives of this report

The TORs were:

A. To provide a systematic and detailed description of MSASs currently in place, wholly or in part, with working examples illustrating functions and outputs.

and

B. To provide guidance on transition from current MSASs to a fit-for-purpose MSAS of the future.
C. To suggest outlines for risk ranking that could aid when designing or adjusting the MSAS.
D. To develop the competency profiles for the risk managers. We foresee at least two profiles one for those responsible for the MSAS at the food businesses and one for the official controls.

It should be noted that maximizing cost-effectiveness and cost-efficiency, together with facilitation of technological innovation, are inherent goals of future MSAS.

We aim to present the current state of play, available knowledge and outline future prospects. The results should indicate the objectives and deliverables of current MSAS in terms of important parameters including meat safety, animal welfare, food/meat quality, ethical and sustainable food production. The results should illustrate the competencies required for the future risk managers. We foresee at least two profiles one for the risk manager at the abattoir or food business operator and one for the official veterinary controls more focussed on verification.

3. Methodology

The working group comprised a group of experts with professional knowledge and experience in relevant areas, whom analysed key elements of the MSAS and assess the potential for integration with the official control. Additional national and international literature (both peer reviewed and non-peer reviewed) and EFSA publications and complemented with their expert knowledge and opinion. This study analysed cases from

different countries on MSAS (poultry, red meat) having regard to their particular their focus and impact along the production chain. The analysis aimed at offering information on the purpose/ scope, methodology, risk-based decision, and performance outcomes.

This report on current MSAS (1) analyses options for integration of MSAS within official controls; (2) outlines to the extent possible the interfaces of MSAS, (3) develops and if possible, validates a conceptual model for MSAS; and (4) outlines future development and utilization of the profile of risk manager. A final objective has been suggesting tools for prioritizing hazards.

We did the work by first reflecting on the boundaries, aims and context of MSAS. This included an analysis of the current legal framework for trying alternative approaches. We also assessed the reports from European Food Safety Authority (EFSA) on meat safety. Assessing strengths, weaknesses, opportunities and threats (SWOT) of different MSAS approaches were the chosen approach to illustrate risks, costs and benefits in the broadest sense.

We present in this report a number of case studies from the RIBMINS member states that highlights the multitude of different approaches possible for MSAS. The examples were presented in a structured form so comparisons can be possible e.g., GHP-based, hazard-based, risk-based provisions, and performance outcomes. Another consideration is the use of private standards as complements or substitutes for the official control. In addition, private standards should also help in the audit and inspections of the food business operators risk management and meat safety assurance.

The WG1 focused on initial stages of production/ processing up to and including the chilling of carcasses. From farm to chilled carcasses, there were more detailed and prescriptive regulations (EU) for official controls and food business operators, while thereafter the regulations are more outcomes oriented and less prescriptive. One should bear in mind that meat food chains are usually integrated to some extent.

We foresee a current baseline averaged from multiple examples from different countries, and identification of achievable improvements that could give the boundaries of fit for purposes MSASs.

The work was carried out electronically and the working group has teleconferenced, had physical meetings in Sofia and Copenhagen, and will discuss the paper during autumn 2020 and winter 2021 for final adoption March 2021. The other RIBMINS WGs were invited to give comments during the summer and autumn of 2020.

4. Collection of information on current MSAS and analysis of context

4.1.Collected information was discussed and analyzed involving MSAS

This report provides descriptions of different MSASs, either in whole or in part, as compiled by members of Working Group 1 of the COST Action “Risk based meat inspection and integrated meat safety assurance” (RIBMINS) CA18105. The report will inform the further

work on the structures and functions of a "fit-for-purpose" future MSAS and aims to provide a roadmap for such a transition.

Table 1 SWOT analysis of MSAS

Strength:	*Weakness:*
Large food business operators often have in-house quality assurance programs in which the MSAS than could be implemented quickly. MSAS are more fit for purpose, flexible and adaptive to changing risks, and cost efficient; compared with a static regulatory approach. Possible to deliver together with food safety also quality, knowledge of origin and provenance, protection against fraud and intentional threats. Possible with better transparency of the meat food chain e.g., for animal welfare.	Plant specific MSASs require large in-house resources both to be implemented and to operate. Thus, the costs could overwhelm small and medium sized meat businesses. The novel roles and skill requirements for the risk managers may require expensive training and novel skills. Food businesses are often small and medium sized low margin operations with limited resources for research, innovation and development.
Opportunities:	*Threats:*
MSAS may open up for more exports if the MSAS is recognized as affording equivalent or better food safety than the current system. Possible to develop collaborative or cooperative MSAS solutions for small and medium sized meat businesses. MSAS could follow industry guidelines that are fit for purpose and adaptive. Evolution of MSAS by learning from best practices and results. Could give a competitive advantage to those meat businesses that adopts MSAS. Easy to integrate food safety with other concerns such as animal welfare and feed safety.	Costs are seen as prohibitive for food businesses. Risk if guidelines or industry standards ends up with box-ticking or compliance into documentation only. Failure to develop a food safety culture Failure to gain acceptance amongst competent authorities and official veterinarians.

4.2.Terminology and scopes of MSAS

There is confusion of terminology and the uses of terms food safety, hygiene, defense, quality, fraud might cause another barrier to understanding, accepting and adapting MSAS.

Food hygiene that is an older term includes to some extent elements of the following terms food safety, food fraud, food defence and food quality. However, these four latter terms are overlapping and sometimes used synonymously thereby creating confusion. Figure 1 outlines the relationship with the four latter food terms with regard to intention and whether the adulteration or contamination cause harm or economic gain. A MSAS appears to require elements of both safety, defense, fraud and quality.

Food hygiene is defined in different ways. For example, Codex Alimentarius defines food hygiene as the conditions and measures necessary for the production, processing, storage and distribution of food designed to ensure a safe, sound, and wholesome product, fit for human consumption. On the other hand, Wikipedia has a narrower definition - **food hygiene** pertains to the practices related to food management and cooking to prevent food contamination, prevent food poisoning and minimize the transmission of disease to other foods, humans or animals. Food hygiene practices specify safe ways to handle, store, prepare, serve and eat food. In Wikipedia food safety is defined as the scientific discipline describing handling, preparation, and storage of food in ways that prevent food-borne illness. The key aim is to prevent unintentional contamination of food that makes the food injurious to health.

Food defense and fraud *relates to intentional adulteration or contamination of foodstuffs (Manning and Soon, 2016). Food defense relates to activities aimed at preventing ideologically motivated intentional adulteration or contamination that makes the food injurious to health. Food fraud is the economically motivated intentional adulteration or mislabeling that may or may not make the food injurious to health.*

Food Quality is defined by Wikipedia as the quality characteristics of food that is acceptable to consumers. This includes external factors as appearance (size, shape, colour, gloss, and consistency), texture, and flavour; factors such as federal grade standards (e.g., eggs) and internal (chemical, physical, microbial). It follows that the for the meat business risk manager the food safety responsibility is not the same responsibility as food quality.

<table>
<tr><td rowspan="2">Consequence of hazard or action</td><td>Gain: economic</td><td>Food quality</td><td>Food fraud</td></tr>
<tr><td>Harm: Public health, economic, welfare or terror</td><td>Food safety</td><td>Food defense</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>Unintentional</td><td>Intentional</td></tr>
<tr><td colspan="2">Intention?</td></tr>
</table>

Figure 1 Matrix of different types of risks to food security. In this matrix the risks are categorized into whether grouped into gain vs harm, and whether the hazard or action it is intentional or not (*Manning and Soon, 2016)*

Codex Alimentarius considers food safety to be assured when the following criteria are met:

- it has been produced by applying all food safety requirements appropriate to its intended end-use;
- it meets risk-based performance and process criteria for specified hazards; and
- it does not contain hazards at levels that are harmful to human health (Codex 2005).

The definition of 'safety' within RIBMINS will follow this guidance, and will focus on assuring a minimal public health impact through meat consumption. While we acknowledge that according to the perspectives of meat business operators, other attributes have become increasingly important in meat production, such as animal welfare, authenticity, labelling, animal welfare, sustainability and composition, and meeting consumer expectations.

Although these attributes are important to consider for social responsibility, and consumer and customer acceptance, they do not need to be covered in a meat safety assurance system. However, if some these attributes e.g., origin are subject regulatory requirements it might make sense for the FBO to include them in their compliance assurance system that will include the MSAS. Furthermore, other systems are in place or are being developed to control and monitor the other attributes, including private standards.

It follows that MSAS or meat safety assurance systems, could be described as the systems for the handling, preparation and storage of meat to prevent and minimize the infectious disease burden caused by meat consumption. This could be seen as the competent authority's perspective. However, one could foresee that from a food business operator's perspective, the meat safety assurance system would probably be embedded in their quality assurance systems indicating a broader scope of the meat industry's MSAS including both meat quality, hygiene and safety.

The proposed MSAS should nonetheless consider the impact of proposed changes on these other attributes when evaluating the benefits, risks and costs of the program. A measure that improves food safety at the expense of animal welfare, for instance, may not be acceptable. Hence, while the primary focus of an MSAS should be on food safety, one must consider possible effects on e.g. animal welfare and health and also considerations of food fraud, defense and quality.

These considerations could be reflected in the distinction of primary, secondary and tertiary scopes of a proposed MSAS. We believe these distinctions could be helpful from an industry perspective when setting up a MSAS (Table 2).

Table 2 Different scopes in regard to meat safety assurance systems

PRIMARY	Meat safety, suitability / wholesomeness, quality, authenticity, animal welfare, food defense, food fraud
SECONDARY	Cost-effectiveness, efficiency, innovation, achieving similar outcomes (equivalence), occupational safety
TERTIARY	Sustainability of agriculture systems (and environment), technological innovation, food security

As these considerations above and Table 2 indicate the risk manager working for the meat business, will have to make decisions based on balancing competing interests and concerns.

Hence in conclusion,

- The scopes for owned MSAS could vary and include other elements than food safety.
- The food safety part of the scope of MSAS should be transparent.
- The scopes of the proposed MSAS should be clarified for each FBO.
- The MSAS will involve the balancing of competing interests and concerns.

4.3.Description of MSAS context and elements

A fit-for-purpose MSAS should be flexible in nature as long as the safety and suitability outcomes prescribed in legislation are met. The MSAS should have output formulated objectives. That is, the objectives should be specified as performance objectives aimed at achieving acceptable risks and related food safety objectives.

Control measures should be implemented flexibly, be evidence-based and adapted to the health status of the incoming animals intended for slaughter. Another concern could be the intended consumption or processing of the meat. Meat intended for canning (corned beef)

The description of a MSAS should include transparent and explicit documentation of the respective roles of the involved food business operators (FBO), competent authorities and any third-party accredited inspection bodies.

While food safety is the primary goal of a MSAS, the MSAS might be embedded in the FBO's quality assurance program with additional aims. The scopes of a quality assurance program beyond food safety, animal welfare and health could be:

- Absence of characteristics objectionable to the consumer - wholesomeness
- Authenticity – the chilled carcass is free from adulteration and is what it says it is
- Specific consumer expectations e.g., organic, halal.

A MSAS has number of elements that are applied at relevant steps in the farm-to-plate food control continuum, with industry and government having both separate and overlapping roles. Industry has the primary responsibility for ensuring food safety and suitability throughout the food chain, while the competent authority has the responsibility for auditing compliance with regulatory requirements and providing final product assurances such as export certificates.

The competent authority has an additional important role in developing the implementation of food safety legislation at national or regional level of each member state, and in addition, providing inputs for the development and evolution of EU legislation. The input from and experiences from the FBOs are needed here. We foresee that a strong culture of partnership is necessary for a successful MSAS.

In conclusion,

- A MSAS should include transparent and explicit documentation of the respective roles of the involved food business operators (FBO), competent authorities and any third-party accredited inspection bodies.

4.3.1 Risk profiling or ranking enabling a fit for purpose and adaptive MSAS

To implement a fit for purpose MSAS we need to have an ongoing assessment or profiling of the risks from animals entering the abattoir and the operations of the slaughterhouse. Risk ranking is one helpful tool for assessing the risks (EFSA, 2018) in the food chain. The ranking risks might be done at different time intervals and different hierarchical levels of aggregation (EU, national, regional, and FBO or site levels).

The EU and national risk ranking should be updated annually and whenever the epidemiological situation changes.

The FBO risk ranking should be updated more frequently and informed by the food chain information (FCI) for each batch of animals. The updates should derive from new knowledge about the farms supplying the slaughterhouses and data about the slaughterhouse itself - results from microbiological monitoring, testing for food process hygiene criteria; and withdrawal of meat from the food chain. Another piece of information is the information from the official control and its audits of the MSAS and other control systems of the FBO. The risk rankings done at the FBO or industry levels should be informed by the rankings done regionally, nationally and the Community (EU) levels.

In conclusion,

- The FBO will own the MSAS but the competent authority will audit the implementation and operation of the MSAS.
- Food safety is the primary goal of MSAS. However, MSAS might be embedded in the FBO's food quality assurance program.
- Risk ranking is a helpful tool for assessing the risks and to enable a risk-based meat safety assurance.

4.3.2 CODEX Alimentarius general principles for national food control systems and for meat hygiene informing MSAS

We believe the Codex Alimentarius general principles for meat hygiene could inform the development of MSAS. An older term used here - meat hygiene is described as all conditions and measures necessary to ensure the safety and suitability of meat at all stages in the food chain (Codex Alimentarius). MSAS can be described as all of those components of food control that collectively assure the safety meat. We believe that the FBO's quality assurance scheme will furthermore include the suitability and wholesomeness of the meat.

The Codex Principles and Guidelines for National Food Control Systems (NFCS) (CAC/GL 82-2013) foresee competent authorities taking into account quality assurance systems in their national food control system. 'Where quality assurance systems are used by food business operators, the national food control system should take them into account where such systems relate to protecting consumer health and ensuring fair practices in the food trade.'

When developing the risk-based MSAS the process should be informed by the Codex Alimentarius code of hygienic practice for meat, CAC/RCP 58-2005, general principles of meat hygiene see Annex. In particular, the points ii and vi provides useful guidance.

In conclusion,

- The Codex Alimentarius code of hygienic practice for meat control is a good point of departure and should guide and inform the development of future MSAS.

4.3.3 Considerations for future MSAS

In addition to the principles outlined by Codex Alimentarius, we believe following principles are relevant for developing the future MSAS. All stakeholders both government, industry and food business operators from farm to fork, 3rd party safety assurance scheme providers, and consumers have roles to play in order to assure safe meat. The focus should be on finding working practical solutions. Moreover, the legal framework needs to evolve further with a view to enable practical MSAS delivering better food safety and cost effectiveness.

The possibilities in the current EU legislation evolution such as pilot trials, proof of concept studies, and comparative studies should be explored to start development of MSAS step by step.

We propose at least two future roles for veterinary inspectors. One role as the risk manager working onsite and employed by the industry or the food business operator, and another role as official veterinary inspector whose primary task is auditing the control carried out by the food business operator and the risk manager. Currently the official veterinary inspector has a major task for controlling individual animal carcasses for cattle, swine, sheep and horses. We foresee that primary inspection role of individual animals and carcasses could be taken over by MSAS staff (auxiliaries and veterinarians) working under the supervision of the risk manager.

This ‘two roles model’ should work well for large slaughterhouses or companies with large in-house resources. However, cooperative or collaborative solutions are needed for medium and small-scale enterprises.

Could for example industry or cooperative solutions where risk managers are employed by the several abattoirs jointly and possibilities for telemedicine solutions in regard to inspection be explored? The use of telemedicine could also open up for greater use of 2nd opinions on findings at slaughterhouses. This could facilitate a more consistent meat inspection.

In conclusion,

- Two roles are foreseen for veterinarians in the future MSAS one as risk manager of the MSAS employed by the FBO, and another one as official veterinarian auditing the MSAS.
- The legal framework needs to evolve to facilitate the development of MSAS
- The current possibilities in EU legislation for studies whose results would inform the evolution of MSAS should be explored.
- The MSAS should take over the primary inspection of live animals and carcasses

- There is need for collaborative industry solutions for the MSAS serving small and medium sized slaughterhouses.
- The potential for telemedicine should be explored for use in small scale slaughterhouses and as possibility for 2nd expert opinions.

4.3.4 MSAS need updated risk assessments

Risk based meat inspection and MSAS will require timely and updated information of human health and zoonotic risks, to function well and be adaptive. Could the food chain information (FCI) provide sufficient information when coupled to EU, national and regional risk assessments? It appears that currently the FCI does not serve as sufficient basis for risk assessment and adapting the risk management i.e., the meat inspection.

The risk assessment should be updated on a regular basis being informed by a hierarchy of sources - EU, national, regional and herd based on FCI. We propose therefore a tiered process where in the first tier - the EU and national risk assessments are done and updated annually and whenever new epidemiological information are available. These tier one risk assessments should inform the tier two regional and local risk assessments – these should also be updated as tier one. The tier three is when assessing risks from the herds of origin, incoming animals, and the slaughterhouse operations. The tier three risk assessments will be specific for each slaughterhouse and will need frequent, possibly daily updating.

In conclusion,

- A working MSAS requires updated risk assessments to adapt and remain fit for purpose.
- The FCI is not yet sufficient to inform the MSAS.
- The risk assessment could be split into 3 tiers tier one a community and national level, tier two – a regional level, and tier three a daily operational level for each slaughterhouse

4.4 Implementation of fit-for-purpose MSAS

We foresee an evolution of the meat control to system of MSASs that the legislation should facilitate. A fit-for-purpose MSAS should incorporate all relevant legislation and be primarily focused on assuring food safety. However, the MSAS might be embedded in a FBO's quality assurance scheme. The MSAS should assure suitability characteristics of meat as specified in legislation, operate in an integrated manner from farm-to-plate, and be tailored to the health status of the slaughter population. It is important that MSAS is designed and implemented in regard to the conditions of the food business operation, the abattoir and the intended end-use of the meat or meat products. One consequence is that the MSAS requires an adaptive risk assessment and management process.

There should be clear differentiation of industry and regulatory roles and responsibilities. For example, the proposed two different roles of the risk manager. The FBO should remain responsible for the food safety and the operation of the MSAS. In particular, for small and medium sized FBOs, it would be helpful if the industry issued guidelines, that the FBO by following this ensured compliance with regulatory requirements.

We believe that the use of 3rd party certification amongst food businesses should be acknowledged and used to inform the food safety compliance audits. Third party certification of MSAS is a promising approach that should be evaluated as soon as practical. The

competent authority should be responsible for auditing the compliance of food legislation including food safety as well as verification auditing and enforcement.

Regulatory requirements should be evidence-based and outcome-focused to the extent practicable, application of HACCP principles and validation of control measures as hazard-based or risk-based where there is sufficient of quantitative information. The monitoring of performance against regulatory and non-regulatory targets would enable the recognition of the equivalence of control measures and MSAS systems.

A MSAS should ensure robust provenance and traceability for meat and meat products, and effectively integrate and utilize safety and suitability information from throughout the food chain. This will facilitate better vigilance against food fraud which is a major threat to the consumer trust in the food chain. The improved traceability will also enable better food defense measures if appropriate given the risk context.

Private and or 3rd party assurance schemes (e.g., British Retail Consortium) for product suitability characteristics such as quality, origin and trademark should be taken into account when auditing MSAS. We foresee that these schemes could contribute to more successful MSAS and further evolution. However, the private assurance schemes do not absolve the competent authorities of their auditing duties.

A MSAS could contribute to surveillance of animal health. This could be the compulsory notification of findings from the meat inspection, indicating suspicion of e.g., foot and mouth disease (FMD), classical or African swine fever (CSF or ASF), or lesions indicative of tuberculosis. Another example might compulsory notification of findings indicating animal welfare risks such as sub cutaneous bleedings or other lesions during transport and lairage. A 3rd issue is the taking of samples for baselines studies of the meat food chain.

MSAS should provide frameworks for setting priorities in surveillance and risk mitigation and clarifying end-points of interventions.

In conclusion,

- A fit-for-purpose MSAS should incorporate all relevant legislation and be primarily focused on assuring food safety.
- The MSAS might be embedded in a FBO's quality assurance scheme.
- A MSAS should ensure robust provenance and traceability for meat and meat products, thereby enabling better protection against food fraud and improving the food defense hurdles.
- Private and or 3rd party assurance schemes for product suitability characteristics such as quality, origin and trademark should improve the functioning of MSAS.
- A MSAS should contribute to surveillance of animal health and welfare, as well as samples for baselines studies of the food chain.

4.5 Ownership and auditing of MSAS

Operation and ownership of the MSAS should be separate from the audit responsibilities of the MSAS. We propose that the FBO either individually or collectively, should operate or own the MSAS. This may require a fit for purpose MSAS for large-scale operations and a more generic industry operated system for small and medium sized slaughterhouses. For

medium and small slaughterhouses, external private consultants, industry associations, and extension services could contribute to the development and the running of MSAS.

The competent authority (CA) should be responsible for the auditing including the approval of MSAS. The difference from today is that officials from the competent authority (CA) will not inspect individual animals. That should hereafter be the task of MSAS and responsibility of the FBO. The focus of CA should be on auditing the MSAS i.e., the risk management of slaughterhouses including compliance, providing risk assessments on the EU, national and regional levels, and updating the food legislation at national level. Another task would be issuing certificates for export and other trade purposes.

This model for MSAS is to some extent already in use for the slaughter of poultry, lagomorphs and fish. The official veterinarian inspects a sample of the slaughtered animals or those the auxiliary has selected either on suspicion or as sample. Usually, the slaughterhouse operator employs the auxiliary. The official veterinarian has more of an auditing role of the meat safety assurance system. We propose to extend this poultry model to the slaughter of pigs, small ruminants, and cattle. Thus, the MSAS we foresee aligns to the meat safety assurance already in place for poultry, lagomorphs and fish.

In conclusion,

- The ownership and operations of MSAS should be separate from audit/control.
- The FBO should own the MSAS either individually or collectively.
- The MSAS should take over the responsibility of the AM and PM inspection.
- This model for MSAS is to some extent already in use for slaughter of poultry, lagomorphs and fish.

4.6 Legal possibilities for changing meat inspection

4.6.1 Regulatory framework - options for integration of MSAS with official control

Regulation (EU) No 2017/625 lays down rules for the performance of official controls and other official activities by the competent authorities of the Member States to verify compliance with European Union legislation in the area of food safety at all stages of production, processing and distribution.

The competent authorities (CA) in the EU shall regulate and control the FBO, based on the risks and with appropriate frequency, taking account of the reliability and results of their own controls that have been performed by the FBO, or by a third party at their request. This might include private quality assurance schemes, for the purpose of ascertaining compliance with the rules in the areas of:

- food and food safety, integrity and wholesomeness at all stages of production, processing and distribution of food, including rules aimed at ensuring fair practices in trade and protecting consumer interests and information, and the manufacture and use of materials and articles intended to come into contact with food;
- feed and feed safety at any stage of production, processing and distribution of feed and the use of feed, including rules aimed at ensuring fair practices in trade and protecting consumer health, interests and information;
- animal health requirements;

- prevention and minimization of risks to human and animal health arising from animal by-products and derived products;
- welfare requirements for animals;
- protective measures against pests of plants;
- requirements for the placing on the market and use of plant protection products and the sustainable use of pesticides, with the exception of pesticides application equipment;
- organic production and labelling of organic products;
- use and labelling of protected designations of origin, protected geographical indications and traditional specialties guaranteed.

Many problems concerning meat safety arise during primary production and have a strong impact on human health. Apart from microbiological hazards, many chemical hazards are found in food of animal origin, as residues of veterinary drugs, residues of unauthorized or prohibited substances, pesticide residues and other chemical contaminants.

FBO's responsibility includes that products of animal origin shall comply with EU legislation in regards to:

- microbiological criteria laid down by Regulation (EC) No 2073/2005
- maximum residue limits for pharmacologically active substances laid down by Regulation (EU) No 37/2010 and Regulation (EU) No 2018/470
- prohibited and unauthorized substances having hormonal or thyrostatic action and β-agonists, in accordance with Regulation (EU) No 37/2010 and Council Directive 96/22/EC
- residues of contaminants, in accordance with Regulation (EC) No 1881/2006 and Regulation (EC) No 124/2009 setting maximum levels for certain contaminants in food;
- pesticide residues, in accordance with Regulation (EC) No 396/2005

In addition, FBOs shall ensure that products of animal origin do not contain physical hazards, such as foreign bodies, which can range from metal or glass fragments, to insects and bones. In case of game meat this might include bullet fragments.

The EU legislation is reviewed and updated frequently. E.g., Regulation (EU) No 2017/625 has recently been updated by Regulation (EU) No 2019/624 (official controls for the production of meat and production and relaying areas of live bivalve mollusks) and by Regulation (EU) No 2019/627 (practical arrangements on official controls on products of animal origin intended for human consumption).

Concerning meat safety, Article 45 of Regulation (EC) 2019/627 lists cases of non-compliance with the legal requirements which consequently, make fresh meat unfit for human consumption. Specifically, some of these are related to the absence of *ante*- and/or *post-mortem* inspection of animals and/or offal, respectively, or meat from animals that are dead before slaughter. Others may be addressed by the implementation of good farming practices and veterinary controls on the farm, or good hygiene practices at slaughter.

Official controls at slaughter are specifically mentioned for *Salmonella* and *Campylobacter* contamination of carcasses (Articles 35 and 36 of Regulation (EU) No 2019/627, respectively). The competent authority shall audit and verify the correct implementation of the Regulation (CE) No 2073/2005 by FBO in regard of the process hygiene criteria for

Salmonella (carcasses of cattle, pigs, horses, sheep and goats and poultry) and *Campylobacter* (carcasses of broilers).

Regulation (EU) No 2019/2090 lays down rules for official controls for cases of non-compliance or suspected non-compliance with the use of authorised, unauthorised or prohibited pharmacologically active substances on food-producing animals and to their residues. In particular, when the maximum residue limits for pharmacologically active substances authorised in veterinary medicinal products or as feed additives, set on the basis of Regulation (EC) No 470/2009 and Regulation (EC) No 1831/2003 have been exceeded, non-compliant carcases and products are declared unfit for human consumption and disposed of as category 2 material, as laid down in Regulation (EC) No 1069/2009. In case of illegal treatment with unauthorized or prohibited substance, carcases or products are declared unfit for human consumption and disposed as category 1 material as laid down in Regulation (EC) No 1069/2009.

In conclusion,

- The EU food safety legislation is very detailed and input based. It regulates the tasks of both the FBO and competent authority in detail.
- Implementing and operating MSAS would require evolution and adaption of EU legislation.
- A more principles based, output or outcome-oriented legislation will be needed.

4.6.2 Legal opportunities for novel approaches and pilot trials

To design MSAS and thereafter develop fit for purpose risk-based meat inspections we must consider the legislation within the European Union. The food controls, and in particular meat inspection, is regulated by three Regulations:

- 2017/625 (official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products),
- 2019/624 (specific rules for the performance of official controls on the production of meat and for production and relaying areas of live bivalve molluscs in accordance with Regulation 2017/625), and
- 2019/627 (laying down uniform practical arrangements for the performance of official controls on products of animal origin intended for human consumption in accordance with Regulation 2017/625).

What are the legal possibilities for testing novel approaches for MSAS in the current legislation? One specific case is Regulation 2019/627 Article 30 that opens up for ending the incisions of the masseter muscle in cattle to detect taenia saginata cysts. Following conditions apply that either having prevalence of cysts of less than a one in a million with 95% certainty, no cases found in meat inspection last 5 years, or no cases found last 2 years and the negligible risk supported by a risk analysis carried out by the competent authorities.

A more general opening is found in Articles 6 of Reg. 2019/627 and 16.2 in Reg. 2017/625 - member states and EU shall take note of current progress in scientific evidence and technical innovation to modernize the meat inspection and control of foodstuffs of animal origin.

Hence, the results of RIBMINS could and should be used to propose changes in current procedures.

In addition, the Article 6 of 2017/627 obliges the member states to notify each other on the scientific and technological developments, for consideration and further action as appropriate. This Article defines neatly the ultimate aims of RIBMINS.

Flexibility of distribution of tasks is possible based on the derogations found in Articles 18 (3) and (9) of Reg. 2017/625 that allow for the reassignment of tasks between official veterinarians and assistants and pilot trials on novel procedures. In particular, Article 18 (9) opens up for member states conducting pilot trials to evaluate alternative practical arrangements of meat safety assurance.

In conclusion,

- Current EU legislation opens up for the possibility of trying out MSAS as pilot or proof of concept studies in current operations.
- Member states are obliged to report to each other scientific and technological progress.
- For the incision of masseter muscles of bovines for taenia saginata cysts there is a special procedure for risk-based adaption and simplification.

Examples of changes include:

- Trying out novel practical arrangements of meat inspection offering equivalent food safety,
- Novel ways division of labor in the slaughterhouse.

4.7 Elements for meat safety assurance schemes

The broad scope of modern meat assurance systems means that we are in the realm of multifactor regulatory decision-making, often having to consider non-food safety (and even non-regulatory) factors when weighting inputs and arriving at decisions. Guidance here is important, especially given WTO-SPS trade considerations of equal protection, evidence-based and proportionate measures. A risk-based meat safety assurance scheme would require a risk assessment that is updated preferably in real time based on information on FCI on incoming animals and slaughterhouse operations.

4.7.1 Risk assessment

Tesson et al., 2020 reviewed different current beef quantitative microbial risk assessment (QMRA) models. There were 67 papers relating to QMRA on beef reported. The focus was on Salmonella and enterohaemorrhagic *Escherichia coli* (EHEC), while other hazards such as *Campylobacter*, *Listeria monocytogenes*, BSE, *Taenia saginata* and *Cryptosporidium parvum* were dealt by one study each.

A concern is available data to the FBO. Monitoring data of food borne hazards are usually only available on regional and national level, and refers to surveys not real time data. A quantitative risk assessment of either microbial or chemical could be helpful on a national or EU level given that the resources and data are more available.

In conclusion,

- QMRA at either EU, national, regional or industry levels could be helpful to inform the FBO risk assessment in the slaughterhouses
- It appears that a QMRA approach is too complex, resource and data demanding for the individual FBO as a daily tool for risk management.

4.7.2 Risk ranking of hazards approach to meat hygiene

The first step in a risk-based approach to meat hygiene is hazard identification. Microbiological hazards that occur in beef, lamb, pork and poultry in Europe and that are transmissible to humans should be identified. This may be achieved using the peer-reviewed literature, textbooks, official data, EFSA opinions, and other sources. Where necessary expert knowledge elicitation (EKE) processes may also be applied.

Once the hazards have been identified, they are then ranked in terms of whether or not they present a high risk and can be controlled by meat hygiene or inspection practices. In other words, we are asking the question; could the public health risk associated with a specific hazard be controlled by effective meat hygiene including inspection. One example is Trichinella in pork where the current meat inspection controls the food safety risks. Another issue is whether the current meat inspections deliver a meaningful reduction of Trichinella risk, as this is an infrequent finding in particular of pigs raised indoors under good biosecurity conditions.

We believe that the EFSA risk assessment done in the modernization of meat inspection opinions appears to offer one template for future risk assessment. This was a simple risk ranking procedure based on the frequency and severity of the hazard in question and whether a chilled carcass could carry the hazard.

A procedure for hazard ranking could be described as addressing two questions systematically to rank the risk from a meat borne hazard as high or low. For example, the following questions could be asked:

1. Is the hazard meat-borne? If yes, hazard included; if no, excluded.
    - Guidance from the following criteria for which at least two should be fulfilled:
        - Carcass prevalence of hazard is above 0.1% according to findings in literature or EFSA reports.
        - Findings in literature (case-control, cohort or outbreak investigations) indicating high relative risk, odds ratio > 3 for catching disease if consuming the meat from a species.
        - Findings in literature indicating a strong association (genetic fingerprinting, case studies, ecological studies) or justifying strong suspicion that meat from a species is a risk factor for catching disease
        - Comparative considerations for example if Trichinella are classified as a high risk in domestic pigs, Trichinella appear also to be a high risk in wild boars.

  - Expert opinion – if there is evidence justified on a case-by-case basis that consumption of meat from a farmed game species is a risk factor for catching disease from a hazard.

  - Successful control effort through meat inspection – e.g., Trichinella in wild boars.

- The hazards introduced during the processing stages are excluded (cross contamination, house floras e.g., listeria)

2. Does the hazard cause severe or frequent disease?

   - Is the hospitalization rate > 100 per million, case fatality rate > 0.1%, or also findings in literature evidencing serious clinical disease for infected persons)?

   - Is the human incidence above 1 per 10000 persons (100 per million)?

EFSA provided a Decision Tree to facilitate this process in their various publications on meat inspection (Figure 2). We believe this decision tree or an adapted one could be practical tools in future MSAS.

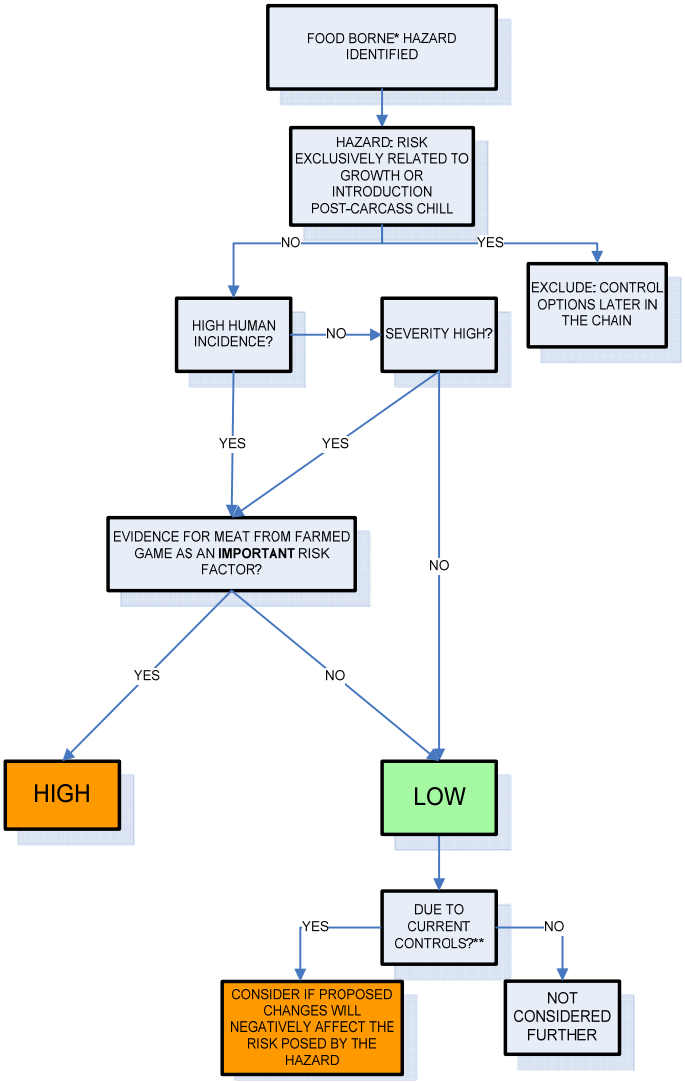


Figure 2 Adapted from EFSA's opinion (2013) on modern meat inspection on farmed game outlining a decision tree for risk ranking of public health hazards originating from chilled carcasses.

For the FBO's risk manager a risk ranking of the identified hazards could be one practical way of prioritizing the risks to be managed.

We suggest that the FBOs risk ranking and management is based on incoming information including FCI at the slaughterhouse and building upon a national and regional risk ranking that is done or supervised by the CA. The national and regional risk assessment would provide the baseline assessment of risks.

In conclusion,

- A risk based MSAS requires real time assessment of risks from the presented hazards.
- Risk ranking could be a practical risk assessment tool for the FBO and as input in the MSAS
- We foresee that MSAS will be embedded in a quality assurance program and that the risk manager will have to deal with quality assurance and economic risks as well.

4.7.3 The Role of Food Chain Information (FCI) in MSAS

The food chain information (FCI) would be critical for the fit for purpose of the MSAS and the risk profiling at the slaughterhouse. One example of the food chain information is (UK FSA cattle https://www.food.gov.uk/sites/default/files/media/document/chapter11-acceptanceslaughter-animals-final-version-2_5.pdf).
Is this FCI example sufficient to profile the risks presented by the incoming animals for slaughter?
In our judgement it appears that while FCI information systems are in operation in most EU Member States, the utility of FCI is limited so far.

To inform the risk management at slaughter the future FCI should identify high priority hazards, and summarize standardized epidemiological indicators for these hazards. FCI could efficiently collect and collate all necessary food safety, animal health and welfare data for wider monitoring purposes.

All involved in the meat safety assurance system, including official veterinarians, official auxiliaries, slaughterhouse staff, farmers, official microbiological and chemical residue testing laboratories, have a role to play in collecting and collating FCI. They should therefore be updated on their responsibilities in a modern MSAS.

A key component of the FCI is the two-way exchange of information between the primary producer and FBO as this should result in better compliance. Moreover, this mutual exchange of information would enhance the contributions of FCI to a more cost-effective meat inspection system.

Food chain information (FCI) is an integral part of *ante-mortem* inspection in modern meat inspection systems and could be the key element in future risk based MSAS, based on streaming incoming batches into high and low risk groups This since the FCI will determine the risk mitigation measures applied at the slaughterhouse. Thus, if animals arrive at the slaughterhouse without sufficient FCI, slaughter of the animals should be treated as high-risk animals.

In addition, the FCI, where relevant should go beyond slaughterhouse and reach food processing plants before meat batches arrives. Ideally also the destination of such batches should be partly defined according to FCI.

To facilitate a risk based MSAS, FCI should include the following information;

- animal identify/tag number
- animal movements over the course of its life
- farm audit/farm related data
- feed composition, storage and use
- biosecurity measures
- environmental management
- mortality data
- veterinary treatment records
- microbial hazards testing data – *e.g., Salmonella, Campylobacter, STEC*
- chemical hazards data – e.g., drug residues, heavy metals, dioxins, …
- information on stocking density
- animal welfare data including housing and handling

- relevant reports of *ante* and *post-mortem* inspections of animals from the same farm
- quality assurance system audit or inspection data, if available
- production data when this might indicate the presence of disease
- name and address of the veterinarian attending the farm
- information on the animal health status of the farm and/or region

What is clear is that FCI is ripe for future developments and improvements. If no data available, perhaps the results from community (EU), national and regional risk assessments could be used.

In a future MSAS, FCI could be used for the following activities:

- ensuring that animals accepted onto the slaughterhouse premises do not come from a farm or area subject to prohibition or other restrictions for animal or public health reasons
- establishing the health status of the animals concerning diseases which are considered of priority i.e., notifiable diseases (such as bovine TB, brucellosis and leucosis for cattle; Aujeszky disease, Trichinellosis, Swine Vesicular Disease for pigs; Salmonellosis and campylobacteriosis for poultry)
- risk categorization of animal herds/lots/batches based on farm descriptors and historical data as well as herd-specific information, including monitoring of harmonized epidemiological indicators (HEI)
- assessment of the risk-associated and protective factors for animals/herds related to specific target hazards
- selection of inspection procedures by the competent authorities (i.e., additional testing at slaughter, application of palpations and incisions following article 24 of Regulation No 2019/627)
- checking for the occurrence of diseases that may affect the safety of the meat and defining the destination of meat batches according to the results;
- ensuring the required withdrawal period for veterinary medicinal products or other treatments has been observed
- facilitating the specific actions targeting high risk carcasses
- forewarning the slaughterhouse of any potential disruption to normal slaughter activities

In conclusion,

- The FCI will be critical for establishing a risk-based meat safety assurance system
- The information in the FCI needs to be electronically updated using access to all relevant data bases containing relevant information
- The current FCI appears not to be sufficient to support a risk-based system.

4.8 A practical approach for risk assessment at slaughterhouses

From a RIBMINS perspective it is clear that risk assessment (most likely ranking) is too cumbersome to be performed on a daily basis. We therefore suggest a tiered approach where the risk manager is:

- firstly, informed by EU risk assessments like the one presented above;
- secondly by any national and regional risk assessment (for example in some countries MRSA is perceived as a risk in pork);

- thirdly by the assessment of the food chain information (FCI) accompanying each consignment.

The risk assessments on the EU, national and regional levels should be updated on a regular basis on the CA's site to inform the risk manager at the slaughterhouse. A practical approach is that the competent authority should provide the risk managers at the slaughterhouses access to the EU, national and regional risk assessments, and notify when updates are available.

The risk manager must assess the risks facing the particular slaughterhouse and assess the FCI of all incoming consignments with a view to take appropriate mitigation actions. The purpose is to categorize the incoming batches according to risk e.g., high and low risk. This could be a tiered approach - the basic risk mitigation must be sufficient to reduce the risks identified on EU, national and regional levels. In addition, if the FBO's risk assessment or the FCI of particular consignment identifies additional risks, then additional measures might be needed.

For example, if slaughtering free ranging pigs, the slaughterhouse could freeze the pork to eliminate *Toxoplasma and Trichinella*. If taking delivery of broilers from a farm with a history of consistent *Campylobacter* contamination in the summer and autumn seasons, the slaughter house could consider freezing the carcasses. The choice of risk mitigating measures should be done in advance.

It is important to recall that the risk manager at the slaughterhouse will deal with a multitude of different risks. In addition to food safety, animal health and welfare, other non-food safety outcomes including authenticity, labelling and composition, as well as consumer expectations. Examples of consumer expectations include welfare, halal, organic, country of origin, and health claims. The company and therefore also its risk manager must also deal with the other risks in terms of food quality, environmental protection, sustainability, occupational health and profitability. The difficult part is the balancing of different concerns and objectives.

In conclusion,

- The risk assessments needed for running a risk-based meat inspection will have to be hierarchical (tiered) from community (EU), national, and regional.
- The community, national and regional risk assessments will be informed by the ongoing monitoring and surveillance activities. These should done be under the supervision of the CA.
    - These risk assessments should be updated annually or when new information is available
- On-site risk management will be informed by the community, national and regional ones, but also consider the farm information, the transport and lairage, the operations of the slaughter house and FCI.

5. A conceptual framework for pork MSAS

A future MSAS will need a carefully designed flow of information between farmer and abattoir as outlined in Figure 4. We can get diagnostic indicators for the pork-borne hazards at farm level by categorization of herds using serological and bacteriological testing of herds. For *Salmonella and Y. enterocolitica, and Toxplasma gondi* sampling of blood/meat juice with serological methods can provide evidence of the exposure of the pig (and consequently of the farm) to the pathogen, but not its current health status, which can be determined by microbiological testing of faeces or lymph nodes. Testing of carcasses at slaughter may not be indicative of the health status on farm, because of post-farm cross-contamination taking place during transport/lairage/ slaughter. In a similar way the findings at AM and PM inspection should also be collated, aggregated and available for analyses by the risk managers.

What is important is the ownership and access to these pieces of information. The slaughterhouse, CA and farmer all need access to these data. For the foreseen risk management model to work, we need real time access to data on the epidemiological indicators. For farmers the feedback will important for their animal health and welfare management.

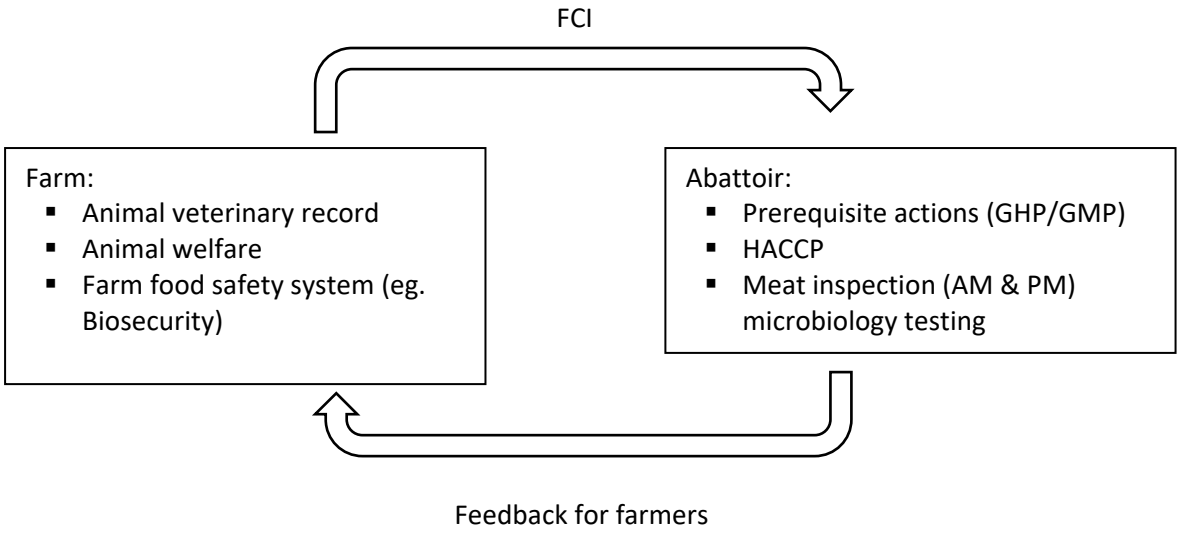


Figure 3 flow of information between farm and abattoir

In conclusion,

- We propose that a regular flow of information between farmer and slaughterhouse should inform the day-to-day risk management.
- These data should be available both for the CA, slaughterhouse, risk manager and farmer
- This would be the key element of the tier 4 risk assessment on site at the slaughterhouse

5.1 Managing pork borne hazards as example

Salmonella* spp. and *Y. enterocolitica - Pigs presented for slaughter may carry *Salmonella* spp. and *Y. enterocolitica* in their intestinal tract and/or on the skin. In addition, *Y. enterocolitica* may be present in tonsils or lymph nodes. Slaughter practices may, in turn, decrease or increase microbial contamination of pig skin; for instance, dehairing, polishing and evisceration increase microbial load of the skin, while scalding, singeing and final washing decrease it (EFSA, 2006). Several measures could reduce *Salmonella* and *Y. enterocolitica* contamination of pig carcasses (Alban and Stark, 2005), e.g.,

- reducing transport and lairage time
- effective sanitation of the lairage environment,
- replacing of tank scalding with spray-scalding,
- plugging of anus before dehairing machine,
- repeating the singeing step after polishing,
- reducing slaughter-line speed,
- hot water decontamination of carcasses,
- complete separation of head from carcasses before any handling, and
- use of blast-chilling.

Interestingly, a 2-log reduction (99%) of *Salmonella* numbers on carcasses, would result in 60-80% reduction of human cases due to pork consumption (EFSA, 2010).

The differences amongst slaughterhouses in terms of reducing microbial contamination of carcasses could suggest the need to categorize abattoirs in respect to risk management abilities concerning *Salmonella* and *Y. enterocolitica.*

Toxoplasma gondii - Laboratory testing only can detect positive pigs, but difficulties are related to low density of parasites in tissue muscle (1 cyst per 25 gram or more). An alternative is on-farm serological testing of meat juice and categorization of farms. Pig carcasses originating from *T. gondii* – infected farms should undergo a reliable and validated cyst-inactivating method, such as freezing (-20° during 11 days) or heating (58 °C for 9.5 min or 61.3 °C for 3.6 min) (Dubey, 1974; Dubey et al., 1990).

***Trichinella* spp.** - does not cause symptoms in pigs and therefore larvae encysted in muscle can be detected *post-mortem* by laboratory testing only. As for *T. gondii*, it seems that inactivation of larvae of *Trichinella* is the most suitable approach to pork safety assurance. For example, meat heating at 71 °C for at least 1 min, freezing at -15°C for 3 weeks (meat pieces up to 15 cm in thickness) or 4 weeks (meat pieces up to 50 in thickness) or irradiation (e.g. 0.3 kGy for sealed packaged food). Smoking and curing are not reliable enough because of difficulties in monitoring and standardized the processes (Gamble et al., 2000).

Since cross-contamination at slaughter does not occur for these parasites, it is not necessary to separate pigs from positive or negative herds.

5.2 Possibilities for risk management of pork borne hazards

EFSA proposed to set ***Salmonella* spp. and *Y. enterocolitica* targets for chilled pig carcasses. These targets should** be achieved by the abattoir, with several degrees of freedom on how to achieve them. Achieving the targets is function of a) abattoir process hygiene; b) presence/level of the hazards in incoming pigs (EFSA, 2011a), this will be the output of the risk analysis (Figure 5).

***Trichinella* spp. and *T. gondii* targets -** The Trichinella appropiate level of protection would be foreseen as no trichinella food safety risk i.e., absence of its viable forms in pork. This criteria would have to be defined as absence in a sample of e.g., 25 grams of pork. This could be achieved through biosecurity on farms thereby ensuring that the compartments were trichinella free, by testing as is the conventional method today or by freezing or heat treatments. A similar approach could be taken for Toxoplasma, although there is yet no agreed acceptable level of protection. Figure 6 outlines a possible pork carcass safety assurance with respect to Trichinella spp. and Toxoplasma gondii (EFSA, 2011a).

Figures 5 and 6 outlines how the the risk management might work. The key principle is to split incoming animals according to the risk they present, at least into high and low risk bacthes, and then to have appropriate processing to ensure the performance objective or prevalence targets on the chilled carcass is met. High risk batches will undergo different handling, additional treatments or processing compared with the low risk batches. Further post harvest, **carcass refrigeration** and **maintenance of the cold chain** will remain key elements of the pork safety assurance framework.

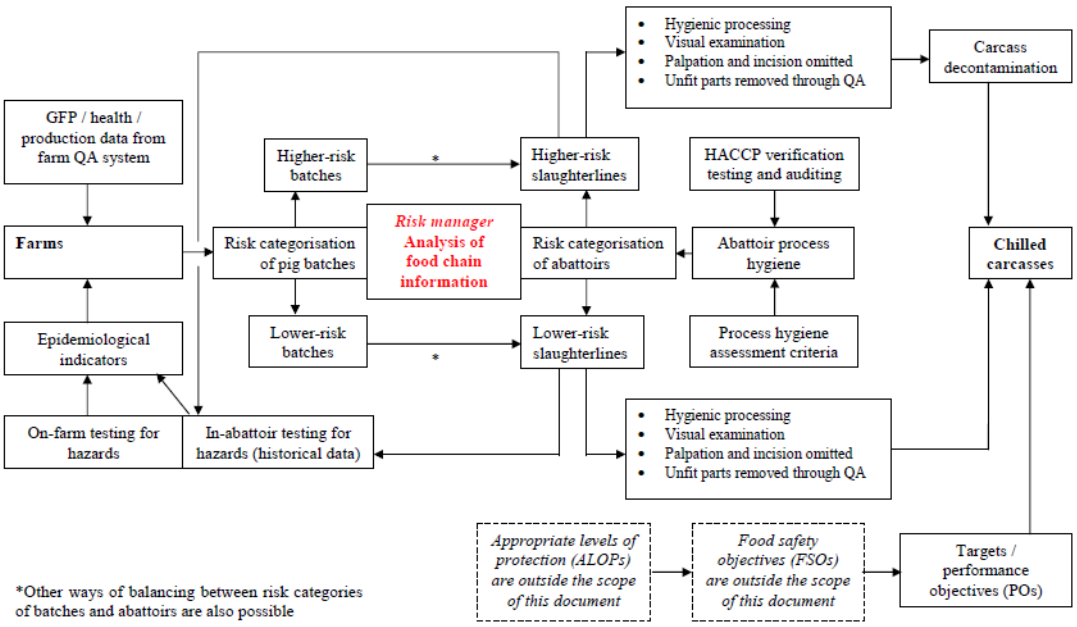


Figure 4 Main elements and linkages of a pork safety assurance system with respect to Salmonella and Y enterocolitica.

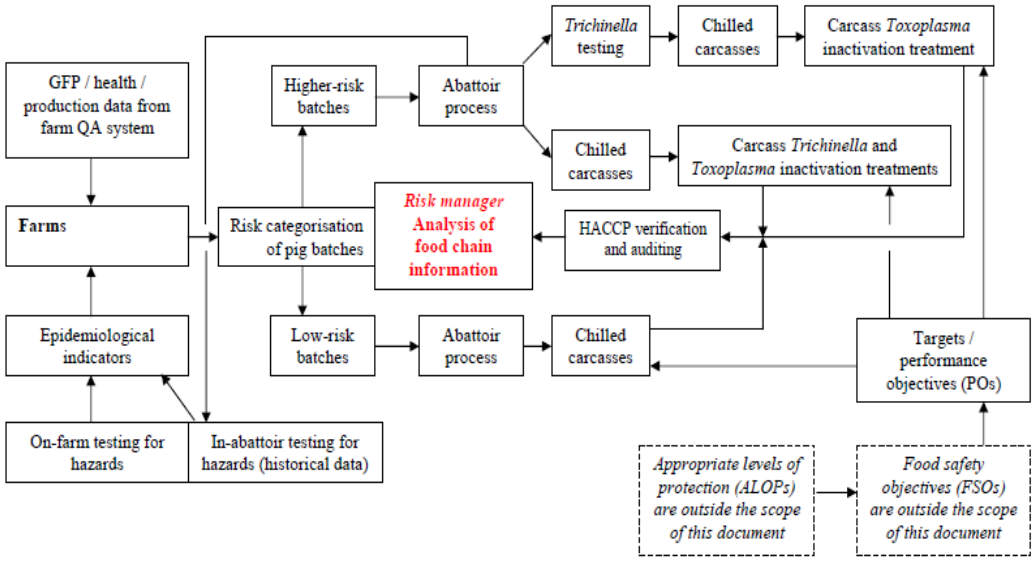


Figure 5 Main elements and linkages of a pork safety assurance system with respect to Trichinella and Toxoplasma.

In conclusion,

- Risk based meat inspection the incoming animals should be ranked according to the risk they present, at least into high or low risk batches.
- the slaughter and processing would have to be different to ensure that both high risk and low batches achieve the same targets in terms of chilled carcass prevalence (performance objectives)

5.3 EFSA model for risk ranking of pork hazards

The EFSA opinions on meat inspection form the backbone for the discussions in RIBMINS on the development of future risk-based meat safety assurance systems. While not a blueprint or template, it gives a conceptual framework for the development of fit for purpose MSAS. The public health hazards to be covered by inspection of pork meat have been assessed by EFSA in 2011 (Scientific Opinion; EFSA Journal 2011; 9 (10): 2351). Figure 2 outlines a simple decision tree that could be helpful in this process.

5.3.1 Hazard identification and risk ranking

The biological hazards were classified according to (see Tables 3 and 4):

- Probability of detection on pig carcasses after chilling –carcass prevalence
- Public health consequences (frequency of transmission and severity of disease)

Table 3 Qualitative risk categories based on frequency of detection of hazards in pork carcasses after chilling

Qualitative category	Descriptor	Hazards in this category
High	> 5%	Salmonella enterica
Medium	0.1-5%	Campylobacter, L. monocytogenes, Y. enterocolitica, Toxoplasma gondii; STEC (at retail)
Low	< 0.1%	Mycobacterium spp., Trichinella spp.
Unknown, but likely to be present	?	Cl. difficile, Cl. perfringens, S. aureus (MRSA), Hepatitis E virus (HEV), Sarcocystis suihominis
Unknown and unlikely to be present	?	Cl. botulinum

Data collected in EU following Directive 2003/99 do not take in account whether pork was identified as a source of human cases. In addition, there is a great variability among reporting countries, and the different notification rates might be not only related to the different incidence of diseases, but also to the different surveillance systems used in different countries. The biological hazards were classified for frequency and severity (case fatality rate) of infection in humans (Table 4).

Table 4 Qualitative risk categories of hazards found in pork based on frequency and severity of infection (expressed as case fatalities) in humans (adapted from EFSA, 2011a)

Qualitative category	Descriptor (frequency)	Case fatality (% confirmed cases) in European Union	
		> 0.1	≤ 0.1
High	> 10/100,00		Campylobacter spp. Salmonella spp.
Medium	1-10/100,00		Y. enterocolitica
Low	< 1/100,00	Cl. botulinum L. monocytogenes STEC	Mycobacterium Toxoplasma gondii Trichinella spp.
Unknown (lack of data)		Hepatitits E virus	Cl. difficile S. aureus (MRSA) Sarcocystis suihominis

Combining information from Tables 3 and 4, foodborne hazards associated with pork was evaluated for their **risk level**, i.e., probability of occurrence against severity of consequences. Severity of consequences is considered high (>10 human cases/100,000 and case-fatality < 0.1%), medium (1-10 human cases/100,000 and case-fatality < 0.1%) or low (human cases < 1/100,000 and case-fatality either >0.1% or < 0.1%).

Final categorization of biological hazards: The biological hazards identified from chilled pork carcasses as a source in the EU were Salmonella spp. (high relevance), Yersinia enterocolitica, Trichinella spp. and Toxoplasma gondii (medium relevance).

The following hazards were not included in EFSA assessment: *Ascaris suum and Echinoccus spp, Brucella suis, Erysipelothrix rhusiopathiae, Streptococcus suis, leptospirae;* as having no association of human diseases with pork meat consumption. *Taenia solium* were not included as not present in Europe in 2011.

However, caution and vigilance are needed recently Taenia solum was reported in Greece (Symeonidou et al., 2018). A risk manager for that particular region of Greece would have to consider these changes, and implement appropriate measures. Furthermore, the hepatitis E virus (HEV) has received more attention as the number of human cases appears to increase both healthy individuals and risk groups. Consuming not heat-treated pork from wild boars and domestic pigs, and venison from deer are the suspected routes of transmission (EFSA, 2017). A risk manager for a pork slaughter-house would have to update the considerations in particualr if the pork is foreseen consumed without heat treatment or other treatments that kills HEV. Both examples illustrate the need for continuous updating of the risk assessment.

In conclusion,

- EFSA (2011) identified 4 pork borne hazards from the chilled pig carcass
  - Salmonella
  - Yersinia enterocolitica
  - Toxoplasma Gondi
  - Trichinella (although controlled by current meat inspection procedures)

- Hazards might emerge for example – the emergence of Taenia solium in certain regions of Greece (Thessaloniki).

- This risk ranking should be updated in light of new information and at least annually.

5.3.2 Evaluation of current meat inspection for pigs

Here we evaluate the current AM and PM meat inspection thereby the current MSAS using pigs as an example.

Ante-mortem meat-inspection of pigs and FCI.
The public health related strengths of *ante-mortem* inspection include:

a. inspection of individual animals
b. animal identification
c. evaluation of animal welfare (e.g., cleanliness)
d. use of Food Chain Information (FCI)

However, FCI is used only to a limited extent (only information on Trichinellosis infection on herd are reported). Since pigs carrying the relevant zoonotic agents rarely show clinical symptoms, the strengths of *ante-mortem* inspection relate to animal welfare and animal health. In this regard, Riess and Hoelzer (2020) noted that a risk-based meat inspection system will require evidence-based innovation to identify what food chain information best predicts herd health and foodborne hazards.

Weaknesses: FCI is not useful for risk management because of the lack of adequate and harmonized epidemiological indicators that could classify the animals according to the public health risks, such as findings of *Salmonella* and *Yersinia enterocolitica or the seroprevalence of Toxoplasma, on the farm of origin.*

Post-*mortem* meat inspection of pigs
Strengths - mainly related to animal welfare and animal health aspects. Classical zoonotic diseases, such as trichinella have become controlled in many countries and the ability of PM meat inspection to detect is only relevant in countries where they are still present. Septicaemia may be detected by PM inspection, as well as before slaughter (on farm or at *ante-mortem* inspection). Septicaemia associated with some foci of infection (i.e. abscesses) can be less acute and detectable only at PM examination.

Weaknesses - the relevant threats to public health associated with pigs (*Salmonella* spp., *Y. enterocolitica,* and *Toxoplasma gondii*) are carried by pigs without symptoms, and the PM meat inspection is not able to detect these agents.

PM inspection can currently detect pathological/anatomical abnormalities in pigs, whose causative agents are mostly non-zoonotic or non-relevant to public health (*C. pyogenes, H. parasuis, Mycoplasma, P. multocida, A. pleuropneumoniae, Streptococcus* spp., *S. aureus).* However, these might important in regard animal health and welfare as well as quality issues and feedback to farmers. It follows that the

How to improve meat inspection - main pork-borne hazards
Since current meat inspection of pigs does not target the most important hazards (*Salmonella* spp., *Y. enterocolitica*, *Toxoplasma gondii)*, the only solution could be setting down appropriate procedures on farm (animal testing prior to slaughter) and at slaughter (e.g. laboratory testing). In contrast *Trichinella* spp. is targeted by mandatory laboratory testing, while derogations are possible according to Commission Regulation (EU) 2015/1375.

In conclusion,

- An effective control of the above-mentioned hazards in pig carcasses is possible only through a more comprehensive system ("**meat safety assurance**") combining a range of preventative measures and controls both on farm and at slaughter in a longitudinally (i.e., vertically) integrated system, including:
- their on-farm occurrence in pigs before slaughter enabling subsequent risk management
- the extent of faecal cross-contamination during slaughter operation (*Salmonella* and *Yersinia*)
- the application and the effectiveness of possible interventions to eliminate/reduce them on carcasses (e.g., decontamination for bacteria; freezing or heat treatment for parasites; heat treatments for meat).
- the possibility of logistic fit for purpose slaughter procedures including interventions

5.3 EFSA risk ranking of beef borne hazards

EFSA (2013- identified salmonella and STEC as main beef borne hazards using the same methods as outlined for pork. Tables 5 and 6 outlines the hazard identification and risk ranking respectively. EFSA proposed to handle salmonella and STEC by establishing targets (performance objectives) on chilled carcasses. This was along the same principles as suggested for pork borne hazards.

Hazard identification

Table 5 Hazard identification of beef borne hazards (EFSA 2013).

	General mechanism of human disease
Bacteria	
Bacillus anthracis	Pulmonary, gastrointestinal or cutaneous infection
B. cereus	Toxicoinfection (diarrheal) including meat-borne; intoxication (emetic) due to starchy foods
Campylobacter spp. (thermophilic)	Gastrointestinal and rarely invasive infection
Clostridium botulinum (non-infant)	Intoxication after multiplication in foods
C. perfringens	Toxicoinfection after multiplication in foods
Listeria monocytogenes	Invasive infection after post-processing introduction and multiplication in ready-to-eat foods
Pathogenic VTEC	Toxicoinfection
ESBL/AmpC gene-carrying bacteria	Antimicrobial-resistant infection
Salmonella spp.	Gastrointestinal and invasive infection
Staphylococcus aureus	Intoxication after multiplication and toxin formation in foods
Parasites	
Sarcocystis hominis	Gastrointestinal infection
Taenia saginata	Gastrointestinal infection
Toxoplasma gondii	Invasive infection

Table 6 Risk ranking matrix of hazards identified for beef borne hazards.

Hazard	High notification rate in humans? (high: ≥ 10/100 000)	High severity (% deaths over confirmed cases? high: ≥ 0.1 % in more than one year)	Evidence for meat from bovine animals as an important risk factor (see Section 2.2.3.2)	Priority category
Bacillus anthracis	No	Yes	No	Low
Campylobacter spp. (thermophilic)	Yes	–[1]	No	Low
Pathogenic VTEC	No	Yes	Yes	**High**
ESBL/AmpC gene-carrying *E. coli*	NA[2]	Unclear[3]	Unclear	**Undetermined**
Salmonella spp.	Yes	–	Yes	**High**
Sarcocystis hominis	No	No	–	Low
Taenia saginata	No	No	–	Low
Toxoplasma gondii	No[4]	Yes[4]	Unclear	**Undetermined**

[1]No need for evaluation according to the decision tree.
[2]No data available.
[3]Based on published evidence.
[4]Based on congenital toxoplasmosis and DALYs.

In addition, the monitoring and surveillance for epizootic diseases such as foot and mouth disease, bovine TB would form an important element in the context where the MSAS is operating. Thus, the risk manager must be able to handle these objectives too.

In conclusion,

- EFSA salmonella and STEC as presenting high risks from beef.
- EFSA proposed to establish performance targets on chilled carcasses for both salmonella and STEC
- The animal health monitoring for epizootic diseases would be an important element of the MSAS.

5.4 EFSA risk ranking poultry meat borne hazards

EFSA (2012 - identified Campylobacter, Salmonella and ESBL as the main microbiological hazards using the same methods as outlined for pork. Tables 7 and 8 outlines the hazard identification and risk ranking respectively. EFSA proposed to handle salmonella and STEC by establishing targets (performance objectives) on chilled carcasses. This was along the same principles as suggested for pork borne hazards.

Table 7 Hazard identification of poultry meat borne hazards

Hazard	Type of poultry
Bacillus cereus toxins	Chickens, waterfowl[1]
Campylobacter spp. (thermophilic)	Chickens, turkeys, waterfowl
Clostridium botulinum toxin	Chickens, turkeys, waterfowl
Clostridium difficile	Chickens, turkeys
Clostridium perfringens toxin	Chickens, turkeys, waterfowl
Escherichia coli (toxicoinfectious strains including verocytotoxin-producing *E. coli*, VTEC)	Chickens, turkeys, waterfowl
Extended spectrum β-lactamase (ESBL)/AmpC (*E. coli*)	Chickens
ESBL/AmpC (*Salmonella*)	Chickens
Listeria monocytogenes	Chickens, turkeys, waterfowl
Salmonella spp. (non-typhoidal)	Chickens, turkeys, waterfowl
Staphylococcus aureus toxins	Chickens, turkeys, waterfowl
Yersinia enterocolitica	Chickens
Toxoplasma gondii	Chickens

[1]Including ducks and geese

Table 8 Risk ranking matrix for poultry meat borne hazards

Hazard	Notification rate in humans	Severity (% deaths)	Severity (DALYs)	Source attribution	Prevalence in carcasses	Risk category
Criterion	(High: ≥ 10/100 000)	High in more than one year≥ 0.1 %	High: ≥ 100 DALYs per 1 000 cases	See Table 4	High: ≥ 5 %	
Campylobacter spp. (including *C. jejuni*, *C. coli* and *C. lari*)	High	Low	Low	High	High	High
C. difficile	Not available	(Expert opinion) High	Not available	Unknown	Not available	Unknown, expected to be low – not considered further
E. coli (toxicoinfectious strains including VTEC)	Low	High	High	Low	Low	Low – not considered further
ESBL/AmpC (*E. coli*)	N/A	(Expert opinion based on hospitalisation rates) High	N/A	High	Not available at EU level	Medium to high
ESBL/AmpC (*Salmonella*)	N/A	(Expert opinion) Low	N/A	High	Not available at EU level (low proportion of resistant isolates using flock data; see Annex D)	Low to Medium
Salmonella spp. (non-typhoidal)	High	Low	Low	High[1]	High	High
Y. enterocolitica	Low	Low	Low	Low	Not available	Low – not considered further
T. gondii	Low	High	High	Low	Not available	Low – not considered further

[1] As shown in Table 4, the attribution estimates vary greatly between MSs, which is considered to be a reflection of the effectiveness of implemented control programmes including for how long the control efforts have been in place.

5.4.1 Evaluation of the current control of poultry meat

EFSA (2012) noted that none of the main biological hazards of public health relevance and associated with poultry meat can be detected by traditional visual poultry meat inspection. EFSA (2012) proposed introducing performance objectives i.e., prevalence targets for (Salmonella, Campylobacter, ESBL-/AmpC-producing E. coli).

During the last 10 years several performance targets for poultry have been established for salmonella and campylobacter. To date (January 2021) the EU has set following prevalence targets for primary production:

1. For **broiler**s by Regulation (EC) No 200/2012 as last amended. The maximum annual percentage **of flocks of broilers** remaining positive for *Salmonella enteritidis* and *Salmonella typhimurium equal* to 1% or less.

2. For **turkeys** by Regulation (EC) No 1190/2012. The maximum annual percentage of breeding or fattening **turkey flocks** remaining positive of *Salmonella* Enteritidis and *Salmonella* Typhimurium to 1 % or less.

- For campylobacter the EU has set process hygiene criteria for **chilled carcasses of broilers** in Regulation (EU) 2017/1495 updating Regulation (EU) 2073/2005. This means that from 2020 out of 50 sampled carcases maximum 15 or 30% of a sample shall contain more than 1000 cfu/g.

5.4.2 Risk management options of poultry meat

These prevalence targets should be reached by MSAS system for poultry meat i.e., combining a range of preventive measures and controls applied both on the farm and at the abattoir in an

integrated way. This could be a fit for purpose approach as the targets are output based. A major advantage is the flexibility and possibility to adapt control programs to local conditions

It follows the thinking for pork MSAS outlined previously. The FBO should have responsibility for such a system while compliance is to be audited and verified by the CA.

The key idea is to differentiate the batches of live poultry entering the slaughterhouse as outlined in Figure 7. For example, if one could categorize the batches as high vs low risk for salmonella and or campylobacter that would be helpful.

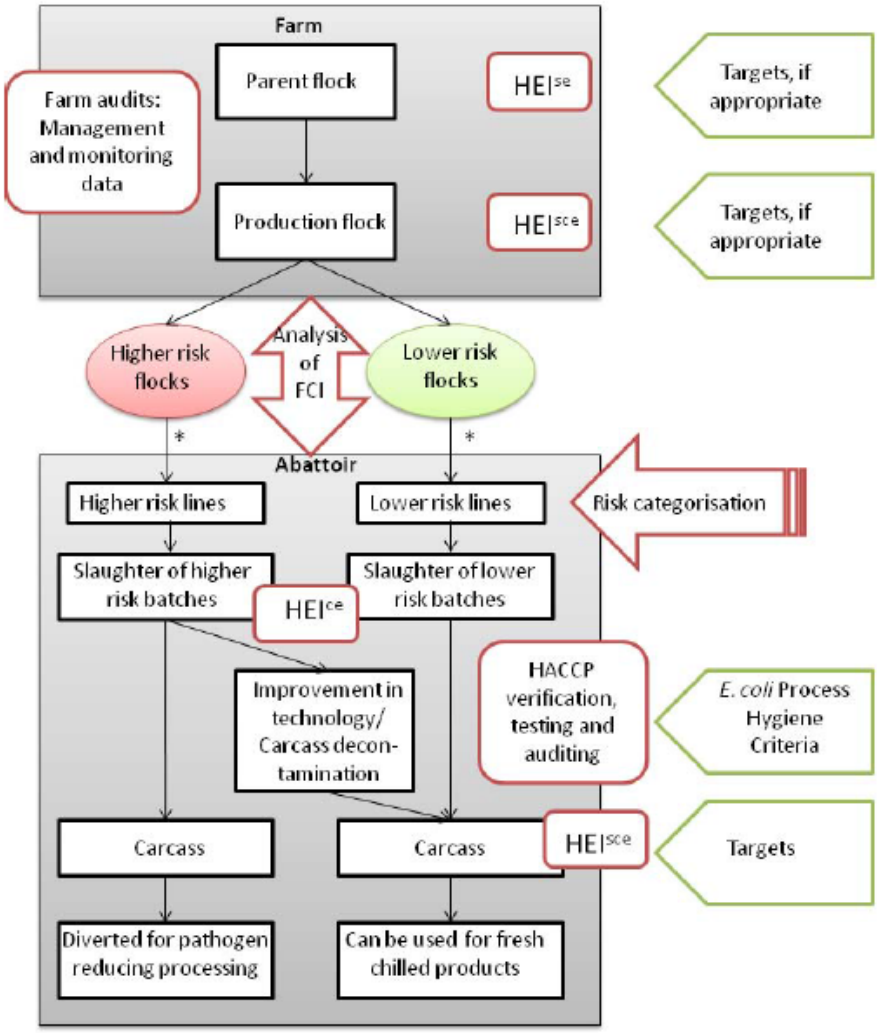


Figure 6 outline of risk management of poultry meat at the slaughterhouse and options for the risk manager

Farm level - the primary goal is reduction of risk for introduction of the main hazards, which can be achieved through preventive measures including flock health programs, including biosecurity and closed breeding pyramids, control of the feed, good hygiene practices (GHP) and good farming practices (GFP). If possible, categorization of poultry flocks could be based on the carrier state of the specified pathogens or farm history thereof. **FCI** could aid in this categorization of poultry batches entering slaughter into at least high and low risk. Pieces of information that aid risk categorization of flocks would include:

- Farm descriptors - using Harmonized Epidemiological Indicators (HEIs) to assess the risk and protective factors for the flocks related to the given hazards.
- Use of historical data. Historical data could include information on previous findings of the hazards on the farm premises or in the parent flock(s) from which the flock originates.
- Data on antibiotic medications

Abattoir level - The differentiation of abattoirs could provide a way of sending flocks presenting different risk levels to adapted slaughter lines or abattoirs based on the FCI. Another possibility would be logistic slaughter based on the risk categorization of the slaughtered flocks; this could be slaughter of higher risk flocks at the end of the day, on special days (at the end of the week), at separate slaughter lines. A third option would be interventions such as the scheduling of higher risk flocks for carcass decontamination or for risk-reducing processes such as heat- or freezing-based treatments to reduce loads of pathogenic microorganisms.

We suggest categorizing the abattoirs according to their capability to prevent or reduce faecal contamination of carcasses based on their technology (methods for reduction of viscera rupture during evisceration or an enhanced washing procedure for birds with ruptured viscera); HACCP and/or process hygiene. Elimination of abnormalities on aesthetic/meat quality grounds can be ensured through a meat quality assurance system into which the MSAS is embedded.

In addition, the monitoring and surveillance for poultry epizootic diseases (Newcastle, Avian Flu) would be an important element of the meat quality and safety assurance systems. Thus, a close collaboration between the on-farm veterinarian and the MSAS will be required to establish risk-based meat inspections.

As part of meat quality and animal welfare assurance, PM checks would done on carcasses being removed from the slaughter line, for example, due to visible pathological changes, damages due to transport and lairage, damages on the slaughter line or other abnormalities. In addition, it is proposed that detailed inspection is conducted on a statistically defined subset of carcasses from each batch, guided by FCI and other epidemiological criteria, to obtain information about animal disease and welfare conditions. The intensity (number of birds sampled per batch) of targeted surveillance within each batch should be risk-based, with sampling of birds conducted randomly to provide a representative picture of the health and welfare of birds in the batch.

To provide a **better evidence base for future risk ranking of hazards**, we need to improve data collection of incidence and severity of human diseases caused by relevant hazards, – systematically collect data for source attribution; and continuously collect data to identify and risk rank emerging hazards that could be transmitted through handling, preparation and consumption of poultry meat.

In conclusion,

- Following hazards were identified as being poultry meat borne – salmonella, campylobacter and ESBL.
- The EU has established performance objectives (prevalence targets) for salmonella flocks and for campylobacter on chilled carcasses (process hygiene criteria)
- The identified hazards are best controlled pre-harvest

- A close collaboration between on farm veterinarians and the MSAS is required.
- FCI could be categorize flocks into presenting high or low risk.
- At slaughterhouse one could then channel the high risk to special slaughterhouses, prescribe logistic slaughter and/or subject to additional treatments.
- The monitoring and surveillance of hazards to animal health and welfare and meat quality should be closely linked to MSAS

6. Residues and contaminants as hazards

Chemical residues and contaminants in slaughter animals do not commonly pose an immediate or short-term health risk for consumers. However, some contaminants may bio-accumulate in the food chain, thus contributing to the overall exposure in consumers. In addition, the presence of certain chemical residues is indicative of non-compliance with existing regulations as well as illicit use of non-authorized substances, with implications for risk management.

The current procedure of meat inspection comprises two major steps at the abattoir level that may result in identifying animals that should be subjected to sampling for the presence of residues and contaminants. The sole intervention at abattoir level is the isolation of a suspect carcass as potentially unfit for human consumption, pending results of residue testing.

AM inspection may identify animals with signs of intoxications, welfare issues or signs of recent medication, such as injection sites, loss of body fat or alterations at the reproductive organs. PM inspection. In most cases, evidence for the presence of chemical residues and contaminants will not be apparent during the current visual inspection of pig carcasses. Therefore, the meat inspection approach based on detect and immediately eliminate is generally not applicable to chemical hazards.

Strengths of the current meat inspection methodology includes:

a) Across EU Member States, residue and contaminant testing is performed by accredited laboratories (ISO/IEC 17025).
b) Follow-up on non-compliant samples through intensified sampling (suspect sampling), condemnation of non-compliant carcasses, and on-farm investigations potentially leading to penalties.
c) The regular sampling and testing for chemical residues and contaminants on national basis is a disincentive for the development of bad practices.
d) The combination of FCI, *ante-mortem* inspection and *post-mortem* gross tissue examination has been frequently found to be supportive to the collection of appropriate samples for residue monitoring.

Weaknesses of the current meat inspection methodology

a) Chemical hazards are not detected by current *ante-/post- mortem* meat inspection
b) Limited flexibility to adopt emerging chemical substances into residue monitoring

In the future the slaughterhouse should be a key monitoring point for baseline studies of chemicals and contaminants entering the post-harvest meat food chain. Hence, it should be clarified whom should be responsible for taking of those samples needed. It would logically

be the MSAS under the CA's supervision. FCI would also be crucial to identify if there are any risks with incoming animals for slaughter.

In the EU (Council Directive 96/23/EC) member states are obliged to implement national residue control plan (NRCP), for defined groups of substances. The groups of substances may be of different concern in carcasses in respect to their illicit use in alive animals (Group 1), their occurrence in feeds (Group 3) or their residues > MLRs (Group 2). EFSA identified no major chemical hazard in their opinions. However, this is a dynamic situation and should be followed up.

The history of feed related scandals e.g.:
- dioxins and PCB in Belgium 1999 (Covaci et al., 2008) that affected 2500 poultry and pig farms,
- dioxins and PCB in Ireland 2008 causing total recall of pork produced in Ireland from September to December 2008 (Casey et al., 2010)
- dioxins in Germany 2011 affecting 4700 German farms both poultry and pig farms (Abraham et al., 2011).

These incidents are reminders of that chemical hazards always must be on the radar for the risk manager in the years to come. In the Wikipedia list of major food contamination incidents, during 2001-20 56 incidents were reported globally, of which 23 were reported in Europe (https://en.wikipedia.org/wiki/List_of_food_contamination_incidents#cite_note-31). Of these 23 more than 20 were related to chemical hazards. This means that a food incident involving chemical hazard contamination are nearly annual events, requiring actions by CA and MSAS. Frequently, these events are linked to contaminated animal feedstuffs.

Rapid action will be crucial for maintaining consumer confidence. It also highlights the importance working feed control and seamless interface between the slaughterhouse risk managers and the feed control. The CA has an important role in facilitating communication along the food chain from farm to fork and ensuring prompt action removing the risks from the food chain.

In conclusion,

- No major chemical hazards were identified by EFSA in their opinions.
- In Europe 1-2 major food contamination events involving chemical hazards could be foreseen annually.
- Handling food contamination incidents will require access to data on the feeding on the farm, medicine and other chemicals used.
- The current meat inspection does not mitigate chemical hazards
- The FCI will be an important control point if including information about feedstuffs.
- The slaughterhouse is a key point for monitoring the magnitude of hazards entering the meat food chain – e.g., baseline studies.
- The interface between feed control, FBO, CA and slaughter house will be crucial to handle and mitigate chemical risks.

7. Private, industry or 3rd party standards or certification schemes

In many countries industry or 3rd party standards or certification schemes are important parts of food safety assurance systems. The food safety elements are often embedded in broader

food quality schemes including both food fraud, quality and safety. The scopes of a quality assurance program beyond food safety, animal welfare and health could include (a) absence of characteristics objectionable to the consumer – wholesomeness; (b) authenticity – the chilled carcass is free from adulteration and is what it says it is (food fraud issues) and/or (c) specific consumer expectations e.g., organic, halal, or locally produced.

We foresee that the MSAS could be embedded or closely linked to these industry standards or certification schemes. This could also offer small and medium sized FBOs a possibility to have a working MSAS without having large costs to establish a bespoke MSAS. Hence, this could be a welcome development enabling the adoption of MSAS in small and medium sized food businesses.

However, it is important the CA do not abdicate their supervisory and surveillance responsibilities. It is possible and indeed preferable that a dynamic evolution of different industry standards will reveal what approaches are working or not.

7.1 Overview of existing certification schemes - food

These industry standards or certification schemes comes in different flavours of which some examples are given in Table 8. They could be classified as:

- **Certification schemes**: Schemes that rely on third party attestation procedure for its members. For the purposes of this study a third-party is a certification body that issues the certificate or statement on the fulfilment of the scheme's requirements.

- **Self-declaration schemes:** Schemes that do not have third party attestation. Adherence to these schemes is done by either a) the scheme operator (in the case where the operator is not a certification body), or b) declaration by the producer or retailer.

- **Umbrella food labelling scheme:** A collection of food labelling schemes with similar characteristics.

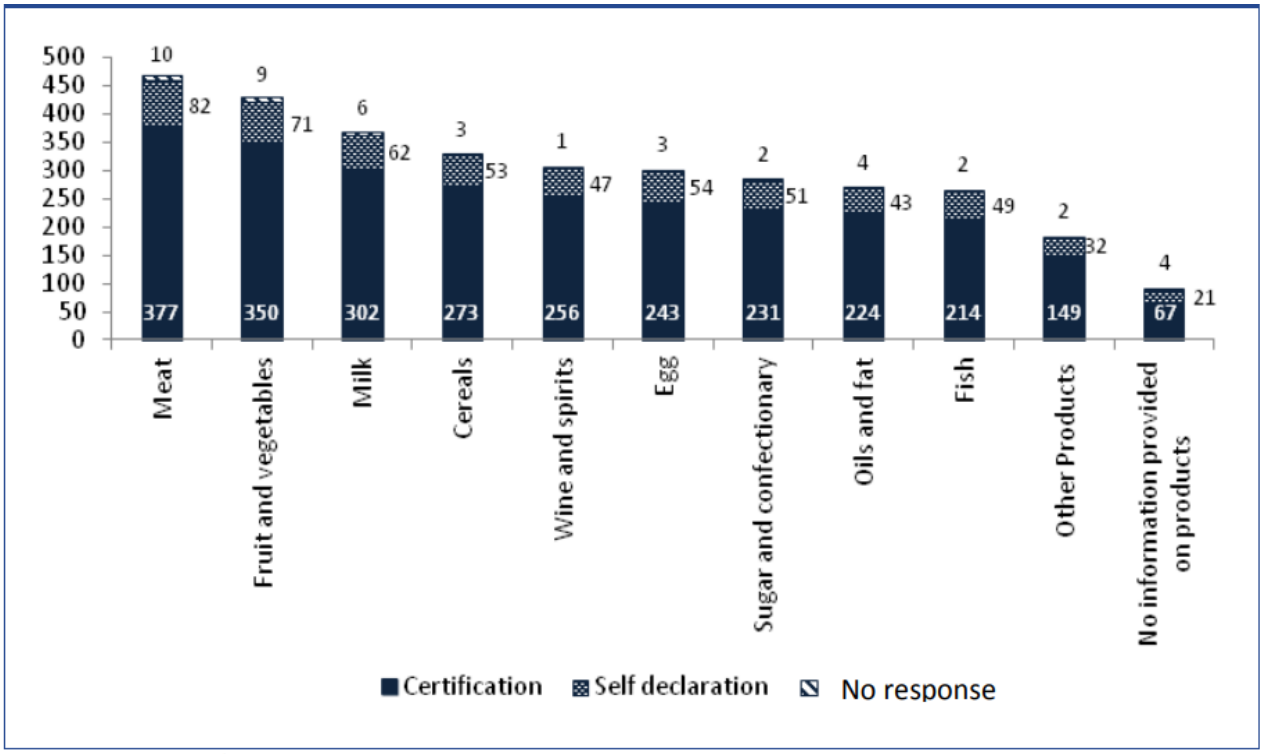
- **Public food labelling schemes**: Schemes that clearly state they are owned or managed by a public body.

*Table 9 Examples of existing schemes**

Scheme	Applicability	Location/Origins	Target	Audience	Type	Safety	Traceability	Sustainability	Welfare	Social responsability
HACCP	Processing			BtoB		X	X			
BRC	Processing	UK	General	BtoB		X	X			
IFS	Processing	Germany, France	General	BtoB		X	X			
FSSC22000	Processing		General	BtoB		X	X			
Global Gap	Primary production	EU	General,Meat	BtoB	Umbrella	X	X	X	X	X
SQF 1000	Primary production	Australia	General,Meat	BtoB		X	X			
SQF 2000	Processing	Australia	General,Meat	BtoB		X	X	x		x
GFSI	Processing			BtoB	Umbrella	X	X			
Global red meat standard	Processing			BtoB						
Carbon trust	Primary production, Processing		General	BtoC				X		
Dutch HACCP	Primary production, Processing	The Netherlands	General	BtoB		X	X			
Fair Trade	Processing		General	BtoC						X
Halal	Primary production, Processing		Meat	BtoC						
Kosher	Primary production, Processing		Meat	BtoC						
ISO 26000	Primary production, Processing		General,Meat					X		X
Organic	Primary production, Processing		General,Meat	BtoC				X		
QS	Primary production, Processing	Germany	General,Meat			X	X		X	

*(more details available at https://ec.europa.eu/info/sites/info/files/food-labelling-scheme-final-report_en.pdf. ; BtoB means business to business, while B to C means business to consumer)

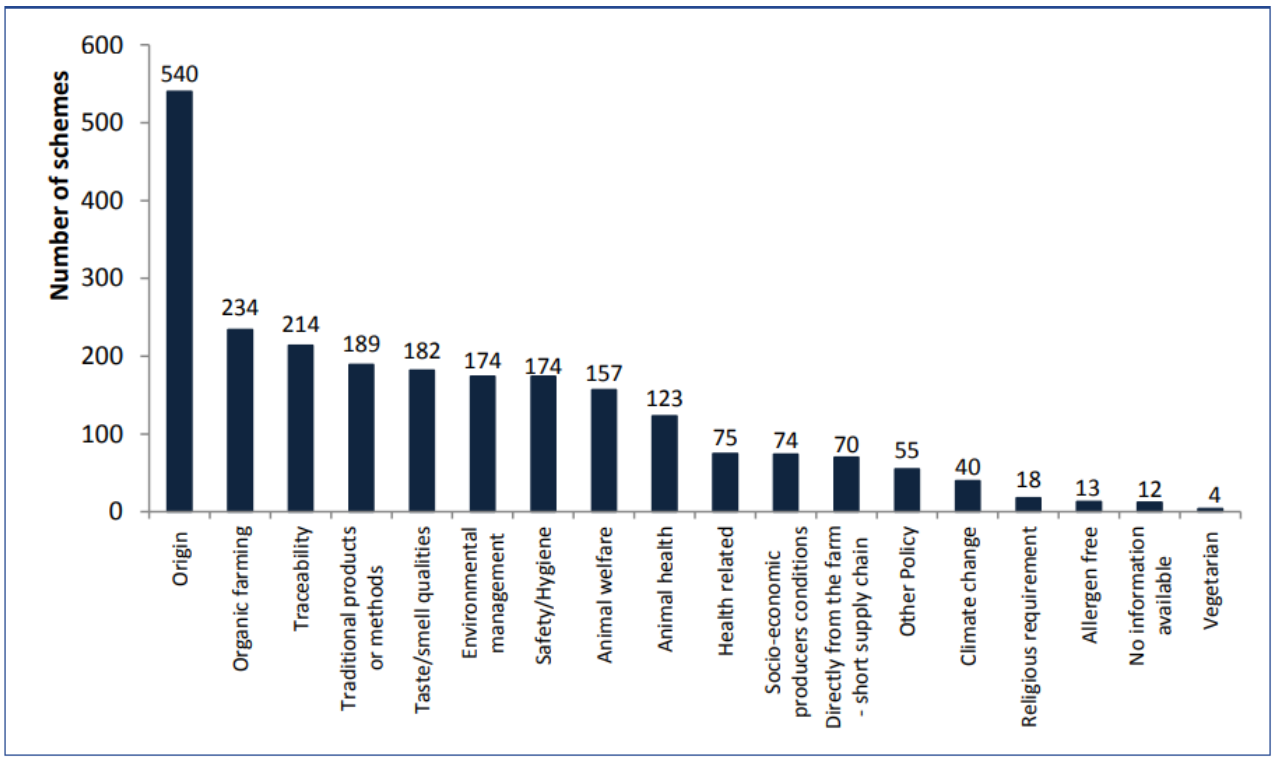
In Figures 8 to 9 the current schemes are outlined. In this study by London Economics 901 different schemes were identified in Europe. As outlined in Figure 8 most are certification schemes and meat are the most frequent foodstuff involved. It appears that around half of the schemes include meat or meat products. In Figure 9 one is looking at food policy areas and more than half of the schemes include the policy on the origin. If looking at Figure 10 the right-hand column on meat products the key policy areas of the meat certification schemes, are safety/hygiene, traceability/origin, animal health, traditional or organic farming, and taste or smell. We believe these schemes could be a basis for MSAS and make implementation easier and more rapid.



Note: The study identified 901 schemes in Europe

Source: London Economics

Figure 7 Number of certification schemes covering different foodstuffs, and whether they are certification or self-declaration schemes.



Note: The study identified 901 schemes in Europe.

Source: London Economics

Figure 8 the number of schemes by policy area.

In conclusion,

- The certification schemes could facilitate adoption of MSAS for many meat business operators.

7.2 3rd party food quality and safety standards

The BRC Food Safety standard provides a framework to manage product safety, integrity, legality, quality, and the operational controls in the food and food ingredient manufacturing, processing and packing industry. BRC Food Safety standard has been developed with an emphasis on management commitment, a Hazard Analysis and Critical Control Point (HACCP)-based food safety program and supporting quality management systems. It is intended to assist organizations and their customers to comply with food safety needs through a foundation of a HACCP or risk-based approach to the management of food safety. Its objective is to focus the audit towards the implementation of good manufacturing practices within production areas with the additional emphasis on areas which have traditionally resulted in recalls and withdrawals (e.g., Label and packing management). These food standards should inform the development of the fit for purpose MSAS.

In conclusion,

- The 3rd party food standards should inform and be integrated with MSAS.

8. Cases from different countries - implemented assurance schemes

Here a few cases from different European countries are presented to exemplify the current state of the art and the wide variations in context and circumstances in Europe. At the same time, most European countries comply with the same EU legislation. It is not intended to be comprehensive but rather give an overview of the variation in local circumstances and contexts and inform the future work. We will also look into the issue of large scale versus small and medium size meat businesses. We will highlight different elements from their food safety systems e.g., industry standards that could be useful in future MSAS.

8.1 Finland

8.1.1 Country structure

In Finland, there are 15 slaughterhouses slaughtering each more than 5 000 red meat animal units or more than 300,000 birds per year, and these slaughterhouses have an adjacent cutting plant in adjacent. Additionally, we have 85 small slaughterhouses, slaughtering 5000 or less red meat animal units and 300 000 or less birds per year. Out of these 85 small slaughterhouses, 56 are active at the moment and 50 of them slaughter less than 1000 animal units or less than 150 000 birds per year at the moment.

All official veterinarians (OVs) and red meat official auxiliaries (OAs) working in slaughterhouses are employed by the Finnish Food Authority, which is responsible for the organization, steering and guidance of official control in slaughterhouses and adjacent cutting plants. The OAs in the poultry slaughterhouses are employed by the company.

The two biggest meat companies in Finland (HKScan: https://www.hkscan.com/en/investors-information/Releases-and-publications/annual-report-2018/ and Atria: https://www.atria.fi/en/group/investors/financial-information/annual-reports/). These companies are also big players in Sweden and Estonia. Hence, meat businesses Finland, Sweden and Estonia could benefit from collaborating on future MSAS design and implementation benefiting from already present business integration.

8.1.2 Towards risk-based meat inspection – prerequisites of risk-based meat inspection of pigs in Finland

This is based the analysis of the case for using FCI and pre-harvest information to inform meat inspection, that was presented in the doctoral thesis of Elina Felin, Helsinki University (Felin, 2019). Could this indicate a way forward for risk-based meat safety?

On-farm health status indicators (such as tail biting and coughing) together with **previous meat inspection results** could be used as FCI to allocate batches beforehand. This would enable decisions regarding the meat inspection procedure: visual-only or additional inspections. The partial carcass condemnation rate for a batch was best predicted by the partial carcass condemnation rate of the pigs from the same farm within one year. In addition, constant coughing and tail biting at a farm were associated with partial carcass condemnations.

As part of a comprehensive pork carcass safety assurance system, serological monitoring of these pathogens could be used to allocate pig farms into risk categories for which targeted control measures could be applied. Risk mitigation targets and procedures could be carefully adjusted for each pathogen.

On serological monitoring - Felin (2019) found that the seroprevalence of antibodies to pathogenic Yersinia spp. was the highest amongst the studied pathogens. The seroprevalences of antibodies to Salmonella spp. and T. gondii were low while Trichinella antibodies was not detected. An interesting finding was that there were large differences between farms for Salmonella spp., Yersinia spp. and T. gondii antibody seroprevalences.

Serological Salmonella monitoring would enable us to follow farm-level trends and detect changes readily and sensitively. Considering Yersinia spp., serological results in FCI would provide the slaughterhouse with the opportunity of logistic slaughter for high-risk batches or implementing other risk mitigating measures.

The seroprevalence of T. gondii was very low. However, the monitoring could be targeted to small fattening farms and outdoor farms. Having the serological results in FCI provide the possibility for slaughterhouses to risk-rank farms according to their T. gondii risk, and to direct carcasses from high-risk farms to freezing or heating.

Serological monitoring of Trichinella spp. is not necessary in the current situation, as virtually all pigs are tested at slaughter using the digestive methods and the seroprevalence is 0%. However, as routine Trichinella spp. testing is to be diminished; sero-surveillance could be used to verify the biosecurity of controlled housing conditions.

In conclusion,

- Records for on-farm health indicators such as tail biting or coughing, previous post mortem findings from a pig herd, and condemnation rates, could be useful for risk-based meat safety assurance.
- The architecture of the data flows between farms, slaughter house and competent authority will be critical for working MSAS. Who owns the data and whom has access to them will be critical questions?
- The usefulness of monitoring antibodies to food safety hazards such as Salmonella or Yersinia could enable adapted risk mitigation strategies at slaughter
- The management of data will be crucial in any MSAS

8.2 Estonia – MSAS

8.2.1 Country structure

In Estonia during 2018, 537 632 pigs, 35 036 cattle, 9 331 sheep and around 12 million broiler chickens were slaughtered. Forty-six companies were authorized to slaughter animals, of which 40 were active in 2018. There are 28 slaughterhouses in Estonia that are authorized to slaughter cattle; 27 slaughterhouses to slaughter pigs; 20 slaughterhouses for sheep; 11 for goats; 1 large-scale for broiler chickens, 2 for horses, and 1 is authorized to slaughter rabbits.

The numbers of slaughtered animals in two biggest slaughterhouses of Estonia were 106 309 and 288 347 pigs and 4 076 and 11 410 cattle, respectively. Currently there are 80 authorized meat-handling establishments (slaughterhouses not included) dealing with production of minced meat, mechanically separated meat, meat preparations and products thereof in Estonia.

8.2.2 Certification of meat industry in Estonia

The certification schemes or industry standards in use are ISO 22000:2005 is used in 8 meat companies and in one FSSC 22000. All other meat enterprises do not have certified food safety systems, but are acting in accordance with Regulation (EC) 852/2004, Article 5 point 1, which says that food business operators shall put in place, implement and maintain a permanent procedure based on the HACCP principles.

8.2.3 MSAS example – vertically integrated management system

Meat Safety Assurance System, the example of the largest Estonian meat company producing both red and white meat. It includes the only large-scale chicken meat production unit in Estonia. The production is integrated vertically through owning or controlling both feed production, farms including farms contracted, slaughterhouses and meat cutting processing plants. This vertical integration enables in house sharing of data.

Vertical integration also enables decisions on where the optimal risk mitigation efforts should be set in either feed production, on farms, at the slaughterhouse or meat processing. Here the handbook of **integrated management system (IMS)** is electronic and available for all company employees, business partners, National Food and Veterinary Authority, and certification bodies. This is detailed overview of the IMS obtained through an electronic

database containing all applicable procedures, instructions, requirements and forms of the meat producing company.

The IMS handbook also provides an overview of the processes and requirements that are monitored in process management. A more detailed description is given in the relevant procedures, manuals and other documents to which the relevant parts of this manual refer. At planned intervals, once a year, the management of the company reviews the IMS to ensure its continuing suitability, compliance and verified performance.

The IMS handbook is intended for:

- communicating company policies, procedures and methods, particularly to employees;
- description and implementation of the integrated management system (IMS);
- continuous improvement of operations and facilitation of verification activities;
- obtaining a documentary base for auditing of IMS;
- to ensure continuity of the IMS and its requirements in changing circumstances.

The meat company has cereal-based full-feed mostly from own production. The on-farm focus on housing with carefully monitored conditions; strict controlled use of medications/antibiotic and hygiene guidelines including all in – all out (batch) production. There are regular farm controls by national Veterinary and Food Board officials in pork and/or beef farms and in broiler farms. The company has its own accredited laboratory carrying out 150 000 analyses per year. Most analyses relate with fresh meat, drinking water and hygiene control for machinery and other production surfaces.

The company's integrated management systems include:

- FSSC **22000** certificate for food safety management system;
- ISO 17025 certificate for laboratory management system;
- ISO 14001 certificate for environmental management system;
- OHSAS 18001 certificate for occupational health & safety management systems.

The goals of the IMS indicate the complex contexts any MSAS will be working within, and include:

1 Ensuring product safety through a risk assessment, prevention and HACCP system for raw materials, production processes and final products;
2 To be reliable and customer-oriented and do not pose food safety risks to consumers;
3 To ensure the safety of our employees through risk assessment of the work environment and the measures taken, and take preventive action to prevent damage to health and the environment;
4 To reduce the environmental impact of our significant environmental aspects through the efficient use of resources and materials and the use of the best available technology;
5 To ensure compliance with legislation and good practices. To contribute company practical knowledge in the development of legislation;
6 Continually improve and share the company knowledge in food safety, the environment and the working environment and direct staff, suppliers, customers and consumers to implement them through the appropriate communication;
7 To require from suppliers and partners to comply with relevant food safety, environmental and occupational safety requirements;
8 To ensure continuous improvement of the management system by assessing the effectiveness of the management system and keeping it up to date.

8.2.4 Food safety risk assessment (ranking)

The IMS Handbook has separate chapters for guidance of food safety risk assessment.
The aim of risk assessment and management is to identify, assess, eliminating or reducing food safety risks to acceptable levels. The procedure applies to the entire production process. The risk assessment procedure is reviewed at least annually or before the introduction of new products and processes as well as after the occurrence of food safety incidents. A food safety team led by a quality manager assesses the food safety risks. The Head of Food Safety has responsibility for assessment of food safety related risks. During the hazard analysis, the food safety team identifies the potential threats/hazards to the product. Examples of threats to food safety may include:

1. Physical hazards e.g., glass, plastic, cardboard, pests, metal.
2. Chemical hazards e.g., excessive amounts of food additives, residues of detergents and disinfectants, lubricants.
3. Biological hazards e.g., *Salmonella* spp., *Listeria monocytogenes*, *Enterobacteriaceae* and their multiplication possibilities in raw materials and / or products.
4. Cross-contamination with allergens.
5. Possible presence of GMO in food.
6. Food adulteration.

The company uses the semi-quantitative scale in risk ranking)
For each hazard, its severity, probability of occurrence and detectability are assessed.
All hazards are assessed on a 10-point system using the following scale

Severity of the hazard:
1 - unnoticeable/negligible
3 - low
5 - medium
7 - high
10 - very high

Probability of the occurrence of hazard
1 - unlikely (1 every 3 years or more infrequent)
2 - probable but rare (once a year)
3 - probable 1 x semiannual
5 - occurs 1x quarterly
6 - occurs 1 x monthly
7- occurs 1x per week
9 - occurs frequently (1 time per shift)
10 - constantly present (each batch)

Detectability of the hazard:
1 – instantly detectable
5 – detected in the next step
10 – not detectable

The multiplication of the grades gives the result where the maximum is 1000 (10x10x10). Multiplication result is a significance index. The results of the hazards related risk assessment are documented. Based on the hazard analyses multiplication results the hazards are divided into 3 categories.

• **Unacceptable risk** – score multiplication result more than 500. Immediate corrective actions must be taken to reduce this risk to a lower level.
• **High risk** - Marked at 300 to 499, HACCP team implements additional hazard mitigation / reduction measures.
• **Low risk** – the product hazard analyses score is less than 299 for which no further action is needed.

8.2.5 Selection and evaluation of control measures

Two main activities related with hazard(s) related risk(s) mitigation are:

1. Carrying out corrective actions to decrease severity and/or probability of the hazard(s) and to increase the hazard(s) detectability;
2. Designating a particular stage as a critical control point or control point.

For each (critical) control point the critical limit(s) and related monitoring system is established to ensure the control of the hazard(s). Additionally, the plan includes corrective actions and their documentation. Following the hazard analysis, an HACCP plan is prepared for each product group. Documents related with hazard analyses are reviewed prior to annual management review and certainly if:
• New technologies are introduced in the production process;
• Technology and / or equipment has been replaced / updated;
• The risk level has changed;
• New information on the impact of the risk factor have become available.

Hazard analyses is documented electronically and available as hazard analyses tables both for beef / pork production unit and broiler meat production units.

8.2.6 Sampling

Sampling and analyses methods are based on Regulation (EC) No 178/2002, Regulation (EC) No 852/2004, Regulation (EC) No 853/2004; Regulation (EC) 2073/2005; Regulation (EC) 2075/2005; Regulation (EC) No 2160/2003, all as amended and their implementing measures, and other Community or national legislation. Additionally, the meat company undertake further sampling and analyses for the purpose of detecting and measuring other micro-organisms, their toxins or metabolites, either as a verification of processes, for food suspected of being unsafe, or in the context of a risk analysis. This applies also to some food safety and process hygiene criteria (additional to those laid down in Regulation 2073/2005) which are set by the company within the framework of the self-control plan. The company has developed guidance documents for sampling e.g. taking faecal, sock and surface samples to detect *Salmonella*.

Samples, an example of broiler chicken meat production

The meat company has laid down company specific criteria in addition to those laid down in Regulation (EC) 2073/2005 on microbiological criteria for foodstuffs. For meat preparations and meat products they include:

- *Cl. perfringens*;
- *Bacillus cereus*;
- *Staphylococcus aureus*;
- *Enterobacteriaceae*.

Production environment surfaces they include:
- Aerobic plate count;
- *Enterobacteriaceae*;
- *Salmonella* spp.;
- Allergen residues tests;
- Detergent / disinfectant residues tests.

8.2.7 Estonia MSAS - RECALL procedure

When a food safety risk is considered unacceptable then a recall of foodstuffs might be needed. In this regard the traceability of the food production becomes crucial to pin-point all food lots representing a risk

Traceability could be described as monitoring/tracking the movement and quantity of the raw materials in production process and tracking of the movement of the finished product during storage and delivery. This could be both forward in the food chain sometimes referred to as tracking and backwards sometimes referred to as tracing.

Recall is the process of removing products that are dangerous or potentially dangerous for human health or by which false information on product characteristics may be given to the intended consumer's e.g., wrong labelling information.

A product must be recalled if:
- Pathogens have been found as a result of microbiological analyses;
- Chemical contamination (including non-compliance with organoleptic requirements) has occurred;
- Not intended foreign bodies (physical hazards) are found in the product;
- It is found that the labelling or packaging of the product does not conform to the requirements.

If information has been derived from the company laboratory, production, customer service, or state surveillance that a product which is delivered may pose a health risk to the consumer, the product recall process is initiated immediately.

Informing stakeholders, procedure
If the case is related with serious food safety risks, then the food safety manager will inform immediately targeted state official(s), and additionally within 3 working days certification company about the recall. The quality/safety manager of the meat company will inform the sate officer of the finding of the pathogen detected in the company laboratory. If it is not

possible to recall the product, the commercial director will inform the consumers about the hazardous products, via the media, if necessary.

Starting and performing the recall procedure
The food safety manager, technologist and food safety specialist will assess the severity of the hazard and identify the related product batch. The movement of the product batch is tracked and remedies are developed (worked out) on a case-by-case basis. The food safety manager of the meat company then makes the order of the recall of the product. Food safety manager will email the information about the product(s) to be recalled to customer service and information about already recalled product to the Production Manager, Sales Manager, Warehouse Manager and Food Safety Specialists. If the recalled product is still located on the premises of the company, its movement will be suspended/stopped, and the batch of the product will be by the food safety specialist labelled as "Non-conforming Product". For products already released from the company, customer service (based on information from the Food Safety Manager) identifies customers who have received the product(s), also quantity of the product, and arranges the recall from the customers.

Handling of withdrawn/recalled products
Products recalled from customers will be immediately directed for decontamination/destroying. Products in the logistics warehouse are destined for either decontamination or reprocessing (if possible). When returning a product, the Food Safety Officer / Warehouse Operator will verify that the amount of product is correct. The quantities of product returned are recorded by the company accountant. Returned products will be diverted to the Animal Waste Management Department for disposal. Products and quantities directed for disposal are tracked on raw material movement tracking sheets. The Food Safety Officer will monitor the further handling of cooked products and, if necessary, take samples from the finished products.

8.2.7. Estonia MSAS Corrective actions

The Food Safety Officer will analyze the possible reasons for hazardous food production, and compile a non-compliance report to implement additional preventive and corrective actions or to improve existing ones in order to avoid possible safety and quality defects in the future.

In conclusion,

- Vertically integrated production systems enable the establishment of MSAS, but are not prerequisites
- The integrated management systems (IMS) from farm to chilled carcass and meat processing enables embedding of MSAS
- The example of risk ranking of hazards is one practical way of handling the risk managers risk ranking problem

In recommendation,

- We recommend vertically integrating meat production systems to facilitate MSAS. This does not necessarily mean one owner or company, but there has to be joint ownership or collaboration of the MSAS along the food chain.

8.3 Italy MSAS Pigs – Parma ham

Structure Italy - Italy is divided in 21 regions. In the Emilia – Romagna region (Northern Italy), Parma Ham is produced in the small territory of Parma province. In Emilia – Romagna region 119 pig slaughterhouses are active. Very different for slaughtering capacity; only 5 can process more than 9,000 pigs/week. Only 10 slaughterhouses are certified to export outside the EU. The Parma ham production is strictly controlled.

8.3.1 Case of antimicrobial residues on pork

During 2017, official controls according to the national residue control program detected sulfadimethoxine in pig meat from a batch of 135 pigs. The level of sulfadimethoxine in meat was 245 µg/kg while the MRL was 100 µg/kg (Regulation EU 37/2010). The FBO traceability system was able to identify all customers supplied with the sulfadimethoxine-positive meat. From the positive batch, a total of 18,000 kg of meat and 270 hams were obtained. However, not all the meat could be withdrawn from the market because 15 days had elapsed before the results were available.

Therefore, fresh meat could not be withdrawn from the market because it had already been sold and probably eaten by consumers. Processed products (cured hams, salami and other products) could be withdrawn from the market because the seasoning period had not yet come to an end (Parma Ham and other long-curing meat products) or because they were still for sale (short-curing sausages salami).

The FBO carried out audits of the pig farm that supplied the animals treated with sulfadimethoxine. The farmer admitted that a mistake was made, i.e., the antimicrobial was given to fattening pigs instead to post-weaning animals on the day before slaughter.

After 270 Parma Hams and other long-curing products had been withdrawn from the market, the Competent Authorities asked to the Italian Ministry of Heath if there could be a tolerance in products whose recipe caused a reduction of the antimicrobials. For instance, salami made of different batches of meat, in which not-compliant meat is mixed with compliant one and other ingredients. In such products, the “dilution” with compliant meat may be effective in reducing the drug level below the MRL. This proposal was accepted by the Italian Ministry of Health and could be applied. On the contrary, products entirely made by meat with antimicrobial residues higher than the MRLs, such as Parma Ham, were to be withdrawn and condemned. The FBO lost more than 70,000 euros refunding all customers.

8.3.2 Case two - Control of Salmonella contamination of pig carcasses

Salmonella is considered a high risk for public health in relation to the consumption of pig meat.

FBO own-check procedure states: The FBOs should met the process hygiene criterion set by Regulation (EU) 2073/2005 as amended. No more than 3 *Salmonella*-positive carcasses out of 50 are accepted. If 4 or more out of 50 carcasses are contaminated by *Salmonella*, the FBO should apply corrective measures.

Following an audit by USA inspectors, the FBO was asked to strengthen the control of *Salmonella*, even if the requirements for pig meat export to the USA were met. Therefore, the FBO decided to control *Salmonella* contamination of pig skin by setting the temperature of water in the scalding bath, at 71.0 °C. The pigs stayed at in the batch for at least 6 minutes. Microbiological testing of scalding water was always negative for *Salmonella*.

In conclusion,

- Recalls are contingent of a working tracing system
- Perishable foods that are consumed quickly might include higher risk for consumer exposures due to incomplete recalls
- Vertical integration is possible without ownership from farm to fork.

8.4 Ireland – Meat Quality Assurance Schemes – Beef, Lamb, Pigs and Poultry

There are several meat quality assurance schemes in the Republic of Ireland, most of which are operated by Bord Bia (The Irish Food Board). All of these schemes are accredited with the National Standards Authority of Ireland and to the European Standard EN45011 / ISO 17065/2012 so they are recognized internationally. The cover from farm including feed production to meat processing.

These include the Sustainable Beef and Lamb Assurance Scheme (SBLAS), the Pigmeat Quality Assurance Scheme, the Meat Processor Quality Assurance Scheme and the Poultry Products Quality Assurance Scheme. The aim of these schemes, which are voluntary and based on current legislation, relevant industry guidelines and international standards, is to promote best practice in farming and processing.

The Sustainable Beef and Lamb Assurance Scheme includes such activities as; [1] stockman ship, capability and competence; [2] identification and traceability; [3] animal remedies and related equipment; [4] animal feeds and water; [5] land management; [6] specified management tasks: bovines; [7] specified management tasks: ovines; [8] animal health and welfare; [9] biosecurity and pest control; [10] housing; [11] transport; [12] environment; [13] farm personnel: health, safety and social sustainability and [15]pesticides (plant protection products and biocides).

The Pigmeat Quality Assurance Scheme covers; [1] identification and traceability; [2] management responsibility; [3] animal remedies; [4] residue prevention; [5] animal feed and water; [6] animal health and welfare; [7] biosecurity; [8] genetics; [9] pest control; [10] housing; [11] pig transport; [12] environmental protection; [13] health and safety and [14] free range farmed pigs - additional requirements.

The Meat Processor Quality Assurance Scheme focuses on control activities in; [1] animal receipt and transport; [2] animal welfare; [3] beef / pig / lamb slaughter process; [4] poultry slaughter process; [5] chilling regimes; [6] cutting and boning; [7] special requirements for value added meat products; [7] inspection and testing meat processor quality assurance standard; [8] final product release; [9] product identification / traceability, reconciliation and recall; [10] handling, storage, dispatch and transport; [11] control of non-conforming product; [12] internal audits; [13] control of inspection, measuring and test equipment; [14] corrective and preventive action and customer complaints; [15] plant and facilities; [16] cleaning and sanitation; [17] pest control; [18] maintenance; [19] breakables; [20] exterior, structure and

grounds; [21] interiors: general; [22] entry to production; [23] interior walls (processing and product storage areas); [24] ceilings and overheads; [25] floors; [26] drainage; [27] doors; [28] windows; [29] lighting; [30] knives, sterilizers, hoses and other equipment; [31] extraction and ventilation; [32] cleaning materials and storage; [33] effluent treatment; [34] food trays; [35] waste disposal general; [36] general; [37] medical records; [38] first aid; [39] personal hygiene; [40] personnel clothing and locker rooms; [41] personnel facilities including canteens; [42] toilet facilities and [43] washing facilities in production.

The Poultry Products Quality Assurance Scheme includes; [1] production site; [2] housing and environment; [3] house preparation 3.5 day-olds sourcing; [4] flock health; [5] feed and water; [6] flock welfare; [7] site hygiene & biosecurity; [8] catching and transport; [9] health and safety on the farm; [10] air quality; [11] environmental protection and [12] free range poultry.

In addition to the above, Bord Bia also operate a scheme to assure the quality of organic food and farming standards in Ireland, which describes the general standards for organic livestock production. The key elements include; [1] the requirements for the separation of organic & non organic livestock; [2] origin of livestock – stricter standards; [3] origin of livestock – EU regulations; [4] conversion of livestock & livestock products – stricter standards; [5] conversion of livestock & livestock products – EU regulations; [5] general management & welfare; [6] livestock housing; [7] bedding materials; [8] livestock diets; [9] products permitted in animal feeds; [10] animal health & veterinary treatments – stricter standards and [11] animal health & veterinary treatments – EU regulations.

In conclusion,
There are following strengths in this set up

- High coverage of Irish food producers
- Accredited to national and international standards
- The schemes are carrying out inspections independently

The weaknesses include

- Operated by a marketing agency rather than science-based organization – conflict of interest?
- Not actively updated
- Reliant on the collaboration with and input from all stakeholders

The threats to these schemes include

- Might become too cumbersome for FBOs and farmers
- Lack of credibility
- Must be updated to stay relevant

The opportunities point also to the possibilities of integrating with a MSAS and include

- Could complement and inform official control
- Work proactively by educating FBOs and promoting a food safety culture
- To actively align the schemes with EFSA opinions and scientific and technical progress.
- Enable to work more risk based

In conclusion,

- The Irish schemes are schemes where a MSAS could be embedded. However, these schemes must be updating continuously and be sufficiently funded, to remain relevant

and deliver high quality control. In this regard some kind of supervision from the CA is needed.

8.5 Sweden removal of Taenia saginata incisions – risk-based meat inspection

One example where the current legislation allows moving to more risk-based meat inspection is the masseter incisions for Cysticercus bovis. The diagnostic sensitivity of the masseter incision is thought to be between 3 - 20% (Eichenberger et al., 2013 and Jansen et al., 2018), This means that only one out of between 5-20 infected cattle will be detected at slaughter. Consequently, the test is useless as meat safety measure for the individual carcass.

However, the incision of masseters has a diagnostic value for monitoring the population cattle going to slaughter. The incision of the heart musculature will remain thereby retaining the monitoring ability for bovine cysticercosis by meat inspection. It can also be used for confirming high risk cohorts. If there are foreseen high-risk situations of contaminated beef with *C. bovis* then the freezing or heat treatments of the beef would be appropriate risk mitigation measures.

Stopping incision of masseter muscles in beef cattle would have the following benefits.

- Economic gains as whole beef more valuable than incised beef – probably around 1-2 M EUR for Swedish beef industry and cattle farmers
- Improved occupational health as masseter incisions is linked to shoulder pains and problems for control staff – fewer days on sick leave
- Longer shelf life of high-quality beef – i.e., better sustainability
- Lower risk of cross contamination of STEC and campylobacters. For example, 1-2% of Swedish cattle carries STEC. Since cattle carcasses are hung up, with heads down, the surface contamination from water at slaughter is present and incision could mean inoculation of the beef with pathogens and spoilage bacteria. This beef is minced and as the custom of not heating hamburgers red in the middle this opens one path for transmission of e.g., STEC to consumers of hamburgers, or cross contamination in the kitchen.
- Possibility of more efficient slaughter lines and control for beef

In Sweden such a process was done during 2020 as a part of the general strategy to make meat inspection more risk based, and thereby modern. According to article 30 of Commission Regulation (EU) 2019/627, the competent authorities may decide that incision of bovine masseters at post-mortem inspection is not compulsory if:

- the prevalence of the source population or in a well-defined subpopulation is below one in a million, has been demonstrated with 95 % certainty; or
- no cases have been detected in all slaughtered animals in the past five years
- no cases have been detected last two years where supported and justified by the competent authorities' risk analysis based on data from reporting carried out in accordance with Article 9(1) of Directive 2003/99/EC.

The competent agency National Veterinary Institute reported one case for the year 2017 (Table 10). Consequently, in Sweden the National Food Authority decided to go for the last approach – 2 years freedom and supplemented with a national risk analysis. This was done during the spring of 2020; masseter incisions were ceased by the summer 2020 and a follow-up 2-3 years later was foreseen to see if the intended benefits and savings were realized.

Table 10 Incidence of bovine cysticercosis according to different notification systems

Year	Nat Vet Institute (verified/# analysed)	Swedish board of Agriculture (SJV)	Swedish annual zoonoses report	Suspected findings at meat inspection	Number bovines slaughtered Sweden
2019					
2018	0/1	4 (M*, N)	0	10	409 349
2017	1/3	2 (M)	0 (1)	5	390 996
2016	0/1	4 (M)	0	7	394 932
2015	0/0	0	0	6	406 628
2014	0/0	1 (M)	0	3	406 088
2013	1/2	1 (E)	1	5	391 347

* County (län) the suspected animal originated (E = Östergötlands län, F = Jönköpings län, G = Kronobergs län, M = Malmöhus län, N = Hallands län, O = Göteborgs och Bohus län).

In conclusion some insights from the Swedish example are:

- Some of the tools used for detecting safety and quality risks from fresh meat have low sensitivity. This means that tools appropriate for population monitoring like this are not really useful for individual animal testing.

- The public health endpoint is hard to measure
  - Infection with Taenia saginata is not a notifiable disease
  - Could proxy endpoints like use of drugs (praziquantelor niklosamid) for treating human taeniosis be used?

- Need to weigh benefits vs risks and costs to make meaningful contributions to risk based meat inspection. How to make simple but sufficient benefit cost analyses and risk benefit analyses seem to be a challenge.

8.6 United Kingdom – Earned Recognition program - possible to embed MSAS?

8.6.1 Synergies of official control with FBO's own checks and 3rd party certification schemes – FVO inspection Oct 2017

The European Commission Food and Veterinary Office (FVO) report describes the outcome of a fact-finding mission of the Directorate-General for Health and Food Safety in the United Kingdom carried out from 4 to 12 October 2017, as part of its planned work program (DG(SANTE) 2017-6069[1]). The objective of the mission was to gather information on the way and the extent to which the competent authorities take account of results of own-checks systems and 3rd party assurance schemes in organizing official controls in food of animal and non-animal origin.

There have been synergies between 3rd party certification schemes and official controls in the United Kingdom for many years. Under the program Earned Recognition, the Food Standards Agency (FSA) recognizes membership and certification for certain schemes for the purpose of reducing the frequency of official controls. Requirements of the program and obligations of the parties involved, namely the Food Standards Agency and the scheme concerned, are laid down in joint memoranda of understanding.

Both the Food Standards Agency and the schemes concerned have introduced measures to ensure the reliability of the information. Some good practices were identified concerning measures put in place by scheme owners or certification bodies to enhance the quality and reliability of the performance and results of their auditors.

These concerned the establishment by a 3rd party certification schemes (PFSS) of the minimum duration of a Private Certification Body/ies (CB) audit based on the size of each FBO aiming to prevent short and superficial audits by CBs, and the IT systems of CBs requiring auditors to introduce a reply to every question on the checklists before an audit can be flagged as closed.

Furthermore, the phase approach of audit including self-auditing, witnessed by purchaser audit and CB audit function as a reminder to the farmers/FBO and staff of the requirements of the scheme and their obligations. They also act as a tool for training staff allowing them to learn what and why something is required under the scheme as well as how and when a check is to be done and where the relevant documentation is to be found or kept.

In addition, there is pre-recognition assessment of the schemes by FSA, thorough theoretical and practical training of (CB) auditors on a scheme's requirements, organized and delivered by the scheme and, witness audits of CB auditors both from the FSA and the schemes owners.

The approved assurance element of the Earned Recognition program is, to date, limited to the primary production sector. However, the Food Standards Agency is currently (2021) exploring the possibility of extending this system to cover also the processing sector by recognizing additional 3rd party certification schemes. The system has led to reductions in the frequency of official controls, freeing up resources for other issues.

[1] https://ec.europa.eu/food/audits-analysis/audit_reports/index.cfm

The degrees of reduction in the frequency of official controls vary across the United Kingdom, even though the same commodities were concerned. In some cases, the frequencies established, effectively mean that some FBO will never be subject to an official control in a lifetime.

Apart from the formalized arrangements for Earned Recognition through membership of recognized schemes in the primary production sector, official controls are delivered on the basis of risk grading of FBOs in accordance with a scoring matrix laid down in the Food Law – Code of Practice. While this code provides for taking into account membership of food producing establishments to non-recognized schemes, this do not influence the final risk categorization in a significant manner.

The major UK food retail chains have in place their own individual company food safety standards for their suppliers of private label products. These individual standards go beyond the standards of the schemes considered as a pre-requisite for FBOs for gaining market access, and often include elements of animal welfare, environmental issues, sustainability, as well as specific product quality standards.

Since these bespoke individual company standards are often used for advertising purposes of private label products, they facilitate the competition between large food retail chains. Food retail chains compete against each other by constantly introducing new standards and requirements aimed at exceeding those of their competitors. These are subject to frequent verification by means of second party audits i.e., retail chains own inspector, of their suppliers.

Although synergies between official controls and 3rd party certification schemes have reduced of official controls and saved resources by the competent authorities, they do not necessarily contribute to a reduction on the regulatory burden of FBOs. This is because official controls constitute only a minor part of the scrutiny the FBOs are subject to throughout a year, compared with the controls carried out on behalf of food retail chains.

In conclusion according to the UK experience,

- 3rd and 2nd party verification schemes could be efficient options in risk based MSASs.
- Often these schemes are linked to food retailers' private labels thereby facilitating vertical integration of the food chain.
- The FBOs regulatory burden may not diminish as the 2nd and 3rd party schemes might just as onerous as the official controls
- The official controls should recognize but also supervise and audit the 2nd and 3rd party schemes if they are to replace the on-site official control
- 2nd and 3rd party schemes could rapidly promote the spread of best practices in the food chains
- The earned recognition schemes could be important elements of future risk based MSAS

8.6.2 Earned Recognition schemes – Red Tractor

Earned Recognition schemes (https://www.food.gov.uk/business-guidance/earned-recognition-approved-assurance-schemes) aims to reduce the regulatory burden for compliant businesses which allows enforcement activities to concentrate problem areas. Those FBOs

qualifying for Earned Recognition will benefit by receiving less frequent visits by the enforcement authority. In England, Wales and Northern Ireland, the FSA is reviewing how private assurance schemes operating in food safety. A guidance on approved assurance schemes, covers the following points:

- criteria details
- process for scheme approval
- governance arrangements
- exchange of information with control authorities

The FSA acknowledges that official controls relating to feed and food safety should recognize those businesses that comply with legislative requirements whilst offering necessary safeguards against unacceptable risk to consumers, animal health and the environment, through the application of appropriate enforcement action to remedy deliberate, persistent or serious non-compliance. Earned Recognition are available to those businesses that are compliant members of an industry assurance scheme recognized by the FSA. Approved status can be obtained by the demonstration of the scheme's compliance with FSA Criteria for Earned Recognition.

The five key areas of assessment are governance, scheme standards, the certification process, the monitoring and review processes https://www.food.gov.uk/sites/default/files/media/document/MOU%20Red%20Tractor%20Nov%202017.pdf.

For example, Red Tractor Assurance https://assurance.redtractor.org.uk/ is a whole chain assurance scheme that covers food safety, traceability, animal welfare and environmental protection. The RTA logo can be applied to food products to show that businesses in that supply chain have met RTA standards and that products are fully traceable back to independently assessed farms.

FSA has a Memorandum of Understanding (MoU) with Red Tractor in England, Wales and Northern Ireland. The MoU outlines the Roles, Responsibilities and General Principles of Collaboration between FSA and RTA.

RTA has six schemes that are approved/recognized by FSA: Beef & Lamb, Crops & Sugar Beet, Dairy, Fresh produce, Pigs, and Poultry. The RTA's meat processing scheme is intended for the slaughter of cattle, sheep, goats, pigs, chicken, poussin and turkey and the cutting and processing of beef, lamb, goat meat, pork, pork sausages, chicken, poussin and turkey. The Certification in this scheme is specific for some business types: abattoir, abattoir and cutting plants, cutting plants, catering, and butchers.

The RTA deals with:
- particular processes (e.g., slaughter, cutting, processing),
- specific species (e.g., beef, sheep meat, pork, chicken, turkey)
- assured products produced (e.g., carcasses/ whole birds, cuts, sausages).

The standards are organized in the following modules: Food Safety, Traceability, Animal Welfare, Poultry Welfare, and Pork Quality. The Food Safety Module includes sections Food Safety Management (FS), Site (ST), Cooked Meats (CM), Third Party Storage (TP) Production and Process Controls (PC) and People (PL). It is applicable to the production of

raw beef, lamb, pork and poultry products and to the cutting of cooked meats. It is not applicable to the production of cooked meats or to sites certified to the BRC Global Standard for Food Safety.

The RTA audits of the system include compliance of the requirements of food safety and the commitment of senior management, effective HACCP and procedures in place. Key points are effective procedures are in place to deal with incidents and limit their impact, complaint management, internal auditing, maintenance of premises and equipment in a manner suitable for food production, procedures and facilities for staff and visitors to uphold hygienic standards, cleaning, control for foreign-bodies and pest control, on-site laboratories and calibration, hygiene storage, temperature control, transport and distribution of meat and waste management.

In conclusion,

- Schemes like the Red Tractor offers a possibility to embed the risk based MSAS into these schemes
- The CA must carefully audit and survey the good functioning of the schemes
- The CA and operator of the quality assurance schemes must formalize their collaboration clarifying the roles, responsibilities and general principles of collaboration.

8.6.3 Integrating private assurance schemes and official controls in the meat sector[2]

The Food Standards Agency (FSA) aims to continuously improve how it regulates food businesses. An example is the FSA's participation in the Risk-Based Meat Inspection and Integrated Meat Safety Assurance (RIBMINS) network, which seeks to "combine and strengthen European-wide research efforts on modern meat safety control systems" (RIBMINS 2019). This analysis feeds into RIBMINS via its Working Group #1 (WG1), tasked with exploring the potential for integration of meat safety assurance schemes (MSAS) into official controls.

While not in the meat sector, the FSA's work on Earned Recognition (Benson 2018) and Regulated Private Assurance (Purcell 2018) has explored using assurance schemes as signals for compliance. The hope is, thus, that work on the matter can contribute to the goals of RIBMINS. At the same time, however, the challenge faced by RIBMINS WG1 goes beyond the development of a national-level program. RIBMINS members share an interest in integrating MSAS into official controls, but their circumstances and, subsequently, the optimal paths forward, can differ. There is, therefore, a need for brainstorming about a rationale that can adapt to varying national circumstances. This analysis aims to contribute to this process of brainstorming by proposing a rationale for MSAS integration that, while offering a sense of direction and relevant guiding posts, is still sufficiently flexible as to consider national differences.

[2] Acknowledging the topic analyses provided in this section by Dr Jose A Bolanos a Research Officer, Centre for Analysis of Risk and Regulation (CARR), London School of Economics (LSE), & Food Standards Agency (FSA). j.bolanos@lse.ac.uk, jose.bolanos@food.gov.uk.

8.6.4 Integrating MSAS into official controls

Assurance schemes, which are also referred to as certifications, are organized efforts that offer a guarantee of adherence to a given set of standards (FSA 2019; Kaechele et al. 2011, 1). These schemes are not as novel as often assumed. The National Fire Protection Agency (NFPA), for example, one of the world's largest such organizations, has been around since 1896. However, assurance schemes have popularized enormously in the past few decades as part of a move from government to governance (Hutter and Jones 2007) that has led to a regulatory system characterized by complex interactions between state and non-state actors (Eberlein et al. 2014; Mills 2016; Lambin and Thorlakson 2018). In the meat sector, for instance, businesses are legally required to meet official controls, but the use of assurance schemes like the ISO 22000 and Red Tractor is now also commonplace.

The increasing popularity of assurance schemes can be perceived as an opportunity. If assurance schemes were to **reliably** deliver adherence to standards equivalent to official controls, official competent authorities could partially rely on them and, in turn, focus their resources on what MSAS do not cover.

Unsurprisingly, examples of efforts to integrate assurance schemes into official controls exist both outside and inside the food sector. An example from outside the food sector is the European Union's Eco-Management and Audit Scheme (EMAS), which encourages the usage of ISO 14001. EMAS has enabled reduced fees for and frequency of inspections, simplified procedures, and reduced monitoring or reporting across the whole of Europe (Dahlström et al. 2003, 188–89). An example from inside the food sector is, as already noted the FSA's 'Earned Recognition' program, which, in the animal feed and food hygiene sectors, aims to reduce inspections for food businesses certified by an approved assurance scheme (Benson 2018; FSA 2020).

Equivalence between MSAS' requirements and official controls, however, does not suffice for integration. The FSA's work on the matter has found that while equivalence is vital, differences "in the purpose, assessment focus and approach" by MSAS mean that equivalence does not equal the ability to function as replacements for official controls (Robinson 2017, 4). This finding is in line with writings about certifications and assurance schemes that emphasize that these cannot typically enforce standards through direct legal sanctions (Cashore 2002, 504; Black 2009, 13). Assurance schemes can, to a degree, punish noncompliant behaviour by refusing (or removing) membership. However, only an official competent authority can force a business to comply with official controls or close its doors.

For these reasons above, assurance schemes should not be understood as control mechanisms but rather, influences to the risk management (Hutter and Jones 2007, 36–39) or, as shown in figure 11, the organizational culture (J A Bolanos 2020, 26) of food businesses. The perceived 'softness' of an influence-like mechanism is a challenge when it comes to thinking about integration into official controls. Food businesses in the meat sector face enormous financial pressures, and even small incidents can have systemic impacts. The massive risk of noncompliance is a concern for official competent authorities because, while the industry is responsible for ensuring food safety and suitability, competent authorities own the responsibility for verifying compliance with regulatory requirements (RIBMINS 2020, 4).

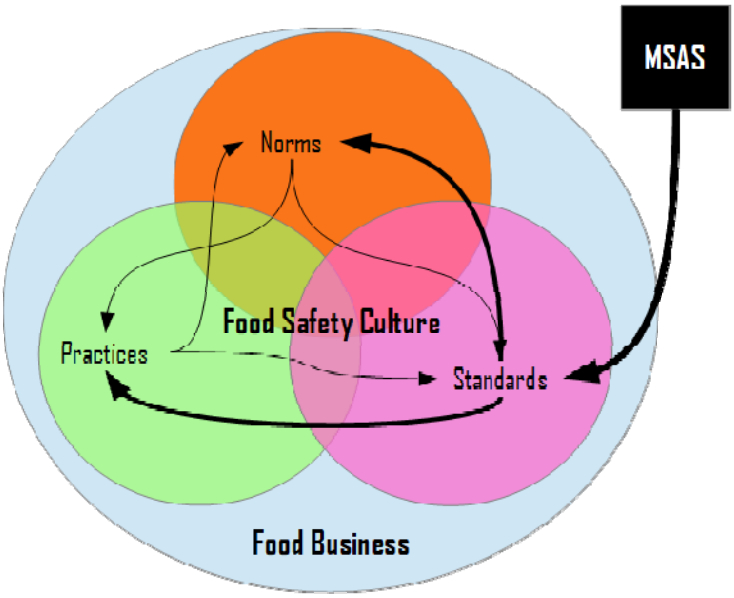


Figure 9 MSAS influence on a food business' food safety culture

For integration to be possible, thus, official competent authorities need to asses not only if MSAS requirements are equivalent but, also, if MSAS can be trusted to reliably deliver adherence despite the enormous noncompliance risks. RIBMINS WG1 must, therefore, ideate a method/rationale to assists members in their efforts to gauge if/ how MSAS deliver reliable equivalence. To this end, the remainder of this paper will focus on the following research question: *how can official competent authorities with common goals but differentiated circumstances*[3] *gauge the equivalence and reliability of MSAS controls*?

8.6.5 An adaptable model

As noted variously, this paper will not present a single recipe for MSAS integration but, instead, a rationale to assist official competent authorities in integrating MSAS regardless of differences in circumstances. This rationale will be presented in three sections: the first concerning equivalence, the second concerning reliability, and a third section about how to approach the general challenge.

8.6.5.1 Equivalence

It would be a mistake to think that MSAS must be equivalent to official controls. Non-equivalent assurance schemes are decidedly not pointless. They can fill into regulatory gaps (Amengual 2010; Montiel, Husted, and Christmann 2012), push practices beyond legal requirements (Barry et al. 2012, 95), and help businesses to meet regulatory requirements (Raines 2002, 425).

That said, the possibility and motivation for MSAS to want to be equivalent to official controls exist. Assurance schemes can offset the need for legal requirements and inspections (Sharma, Teret, and Brownell 2010, 240; Higgins, Dibden, and Cocklin 2008, 25), and uptake of these schemes is higher where it is possible to use them to substitute regulation or inspections (Anderson, Daly, and Johnson 1999, 40–41). Thus, many MSAS may opt to be equivalent to official controls in at least some respects.

[3] A terminology inspired by the idea of 'Common but Differentiated Responsibilities', native to the field of climate change.

There is a world of possibilities implied in the above, though. An MSAS that simply mimics the law is unlikely to be able to frame itself as providing much additional value to members. Similarly, if all MSAS were equal, they could not frame themselves as better than competitors. So, there is a need to identify the aspects in which different MSAS are equivalent to official controls, and it would be helpful also to learn if the equivalence is due to having equal requirements than official controls (process-based) or enabling equivalent results (outcome-based).

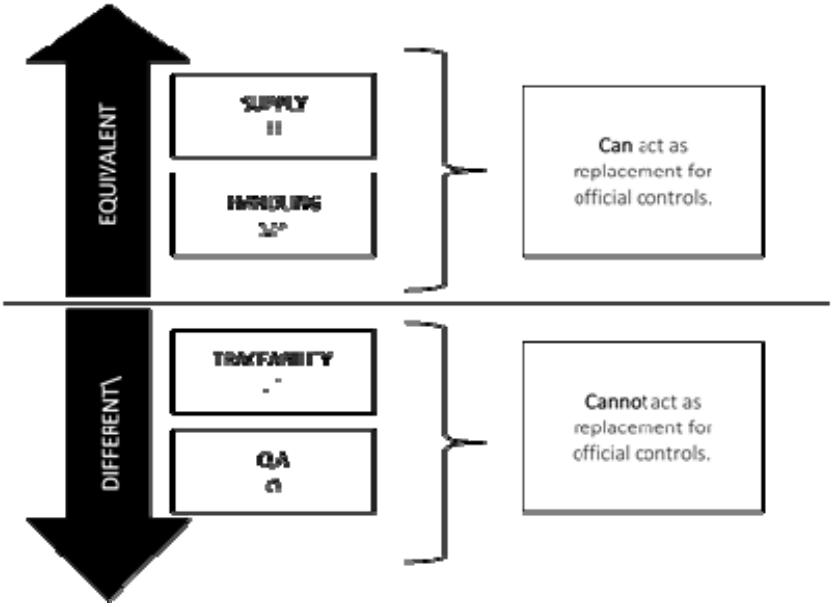


Figure 10 Equivalence component.

As shown in figure 12, it is possible to do the above by dividing MSAS requirements into categories[4] and using a four-step rank to specify the degree and form of equivalence:

- High (H): equal outcome;
- Medium (M): very similar process but slightly different outcome;
- Low (L): minimal similarities in either process or outcome;
- Null (∅): entirely different from official controls.

It is necessary to validate the categories and ranks with real-world cases before committing to them, which will be addressed later in this paper. However, the specific goal in this paper is to propose a rationale that enables such validation. The categories and ranks above suffice for this purpose.

8.6.5.2 Reliability

As already noted, the second part of the challenge is reliability or, to say more completely, the ability to trust that MSAS deliver in practice. As also noted, this challenge results from MSAS inability to enforce compliance like official competent authorities do.

[4] The categories used in this picture are tentative and need to be revisited at validation stages. Additionally, a caret (^) is added when, separate to considerations of equivalence, MSAS requirements can serve as a foundation for synergies (i.e., complement official controls).

A way to approach reliability is to think about the implications of having more/less independent MSAS, a discussion that links to writings about the independence and accountability of non-state actors involved in regulation (Alkoby 2003; Mattli and Büthe 2005; Black 2008; Mattarocci 2013; Anand and Sossin 2018). For an MSAS that is entirely independent of the law, revoking a membership is a punishment with economic implications. An MSAS that is required by the official competent authority to ensure businesses meet some thresholds is less independent but can, by removing membership, render the business unable to operate – a more significant punishment. In sum, then, requirements by official competent authorities limit MSAS independence but, at the same time, can increase their enforcement capacities.

As is the case of virtually everything in life, extremes seem nonsensical. Total control over MSAS would limit their ability to add to the law. Completely ignoring MSAS would limit competent authorities' insight and, subsequently, the room for cooperation. However, middle-range alternatives exist, are visualised in figure 3, and elaborated in the next page.

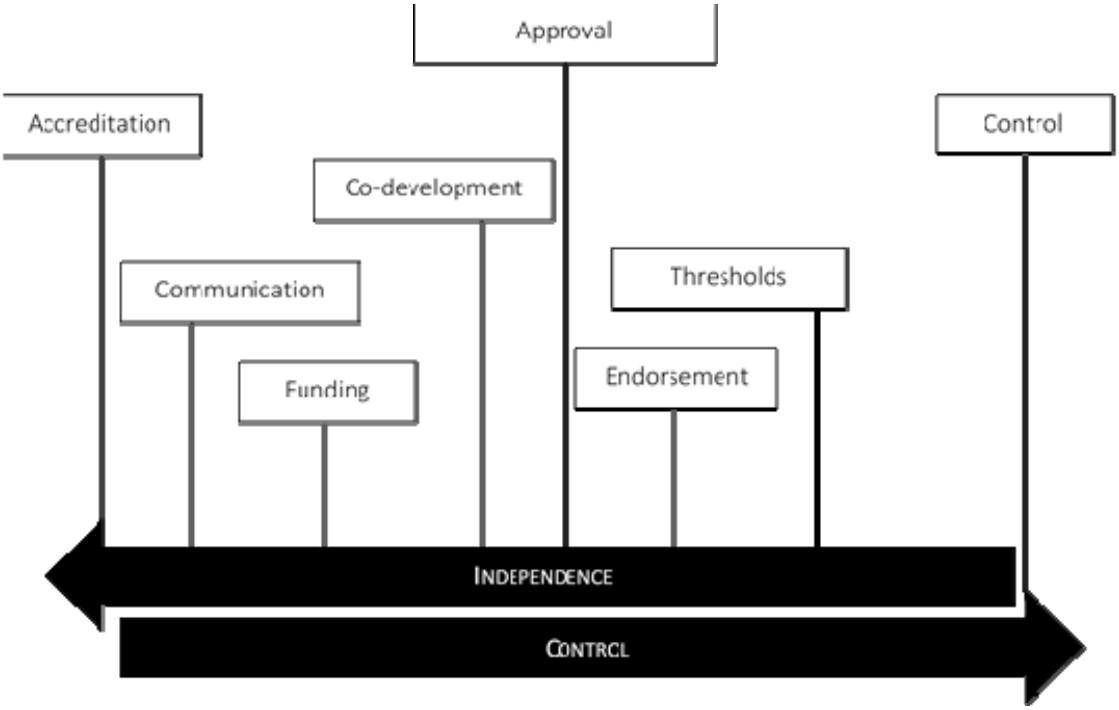


Figure 11[Forms] of reliability component

The extremes in figure 3 speak of near-total independence and control. In countries with the rule of law, there is typically a background of rules that constrains the operation of all organizations (Héritier and Lehmkuhl 2008). Furthermore, many countries require assurance schemes to accredit themselves with national standards body like the United Kingdom Accreditation Service (UKAS). However, accreditation does not speak of any direct influence from an official competent authority. At the other extreme, a competent authority unwilling to heed the advice above may opt to force MSAS to certify only against the rules given by the competent authority, rendering service providers out of MSAS.

Influence from competent authorities can increase variously, though, without, in doing so, enslave MSAS. Communication can lead to a degree of coordinated action. Funding by competent authorities is bound to mean additional influence over MSAS. An official competent authority can take a co-developmental role, which would mean impact directly

into (but not control of) the design of an MSAS. These options mean few direct regulatory constraints over MSAS but, at the same time, only yield minor increases in MSAS capacity to motivate compliance with their requirements.

Real enforcement capacity starts to be feasible alongside requirements that can lead to banning activity by noncompliant members. A competent authority might create a minimalistic process for MSAS approval with no specific rules but the possibility of reduced inspections, much as the FSA's Earned Recognition does. This option would increase the appeal of complying with the requirements by MSAS and, subsequently, raise the impact of losing membership. Going further, a competent authority could endorse a few MSAS based on an evaluation of their quality, thereby allowing these selected MSAS to be somewhat more bullish in their verification efforts. Next, a competent authority can ask all MSAS to include minimal thresholds in their codes and attach MSAS' own right of operation to continued verification of these thresholds. In this approach, the responsibility for verification of some requirements would be transferred to the MSAS, and the regulator would need to ideate processes to inspect, not businesses, but MSAS.

This section does NOT argue that a specific independence/control approach is inherently better than others. All the arrangements noted above exist (Barry et al. 2012, 74–75) and, therefore, must be considered as part of the spectrum of possibilities open to RIBIMNS members.

8.6.5.3 A note on combined usage of MSAS

For ease of reading, the analysis of equivalence in the text is based on a single MSAS. However, as shown in table 11, it is possible to use the rationale in the paper to consider multiple MSAS.

The combinatorial approach in table 11 may not be necessary for integration efforts at the MSAS level. If MSAS participate, equivalence can be calculated for each, and food businesses using more than one MSAS would simply benefit multiply. However, the ability to consider multiple MSAS in a single table could be helpful for business-level approaches, as it would allow businesses to submit information about their usage of various MSAS.
Elaboration of table 11 and how MSAS combinations can be gauged is needed but, at the same time, dependent on context.

Table 11 Combination of MSAS

	MSAS 1	MSAS 2	MSAS 3	COMBO
SUPPLY	L	L^	M	M^
HANDLING	H	M	L	H
TRACEABILITY	M	M	L	M
QA	L	L	L^	L^

8.6.5.4 Paths to integration

Given the above, two plausible approaches to managing integration exist. These two approaches are broadly describable as Earned Recognition (Benson 2018) and Regulated Private Assurance (Purcell 2018).

- **Earned Recognition**: When there is little direct enforceable authority from competent authorities over MSAS and, subsequently, MSAS over members, the possibility of defection is unavoidable. Integration is, therefore, best pursued through information sharing arrangements that serve as signals for reducing inspections.
- **Regulated Private Assurance:** When there is a possibility for enforcement, integration is best pursued by developing a regulatory framework that covers, at once, MSAS and their relations with members. For instance, regulations asking MSAS to ensure members meet 'X' are best when accompanied with regulations requiring food businesses to use MSAS – so that MSAS can charge as much or as little as needed for their services to include due auditing.

The question of which is the best path for integration in a country comes down to whether that country can change the independence/control ratio. If a country cannot change this ratio, it likely is because it cannot impose requirements on MSAS. For these countries, an Earned Recognition approach seems the only viable path of action. If a country can change the independence/accountability ratio, though, a regulated private assurance approach would require:

- Determining the aspects in which MSAS ought to be equivalent.
- Transfer the responsibility for verification of these aspects to MSAS.
- Require usage of MSAS by food businesses.
- Create a process of MSAS approval and attach approval to 'quality assurance' clauses that guarantee the ability to oversee or sample the work by MSAS.

8.6.5.5 Validation alternatives

The rationale above offers a framework that is adaptable to different national circumstances and seems able to guide participating official competent authorities in their efforts to maximize the benefit they derive from the existence of MSAS. Before conclusions and recommendations are possible, however, there is a need to validate the rationale with real-world cases. The FSA already has a relation with MSAS in the UK. Therefore, it is reasonable to think validation could be pursued at the general MSAS level. That said, it is essential to clarify that validation is also possible at the business level and does not necessarily require involvement by MSAS.

All the above tells that there is a need to determine (#1) if MSAS are equivalent, and (#2) if they deliver reliable adherence. However, nothing above implies that these two analyses must happen at once. It is entirely possible to separate these two aspects of the analysis into two acts involving different actors:

1. Determine the equivalence of MSAS in a country, which official competent authorities can do regardless of whether MSAS participate or not.
2. Develop a method by which food businesses can opt into voluntary information-sharing agreements about their implementation of MSAS.

In this way, even if MSAS are unwilling or unable to share information for all members, *some* of these members may still want to enhance the value of their membership by volunteering this information.

8.7 The Netherlands –Supply Chain Meat Inspection pork

In the Netherlands a novel Meat Safety Assurance System called the "Supply Chain Meat Inspection" was implemented for pork production in 2006. The general idea was a holistic HACCP approach to the assurance of meat safety for the Dutch pork production and taking into account hygienic measures throughout the entire chain of production. The farm assurance system in which the pigs were raised under, is seen as an important basis to control relevant hazards to human health. Only pigs originating from farms participating in assurance systems recognized by the competent authority are allowed in this system. The idea of including critical control points at farm level which can be verified at the abattoir level are a clear example of the holistic approach.

8.7.1 Risk ranking of hazards

To identify relevant hazards for food safety the system uses data on human incidences of foodborne illnesses. The frequency of occurrence of illnesses and the severity of the illness i.e., disease burden, are used to calculate the relative relevance of the hazard causing the illness. This relevance is connected with the source attribution – is pork a main source of the food borne hazard?

To illustrate; foodborne illness caused by salmonella sp. are frequently reported to be attributed to pork consumption. The onset of such an illness can be very severe and the hazard *salmonella* sp. is therefore identified as a high-ranking hazard in pork production (Figure 14). Campylobacter as another example can cause severe illness but is not frequently attributed to the consumption of pork. This hazard is therefore identified as a less high-ranking hazard in pork production. The process is done for all known hazards in pork production. The list is dominated by hazards such as salmonella, toxoplasma, listeria and mycobacteria.

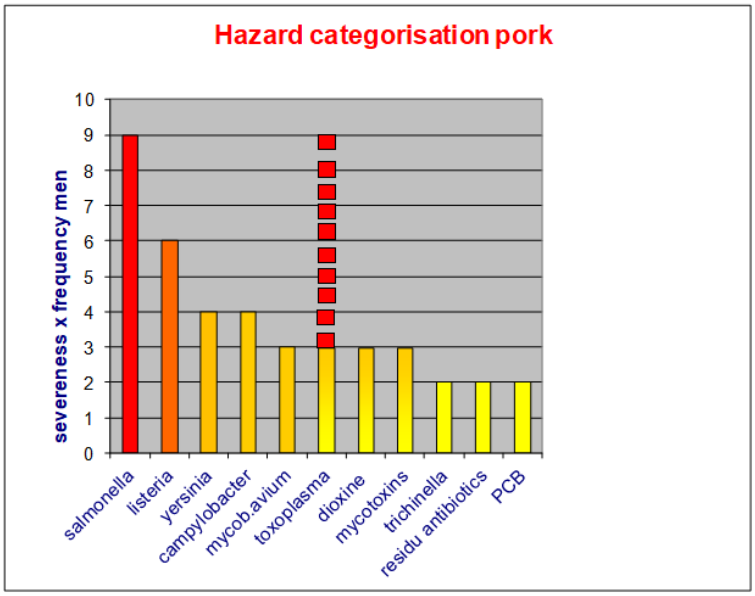


Figure 12 Hazard categorization Pork - Supply Chain Meat Inspection program Netherlands. When taking into account the effect of toxoplasma on the health of unborn individuals the relative position moves towards the left as the disease burden of toxoplasma increases.

For these high ranked hazards specific control measures have to be identified and implemented at the most efficient spots in the production chain (Fig 15). This could both mean (critical) control points at farm level, slaughter and/or at further meat processing.

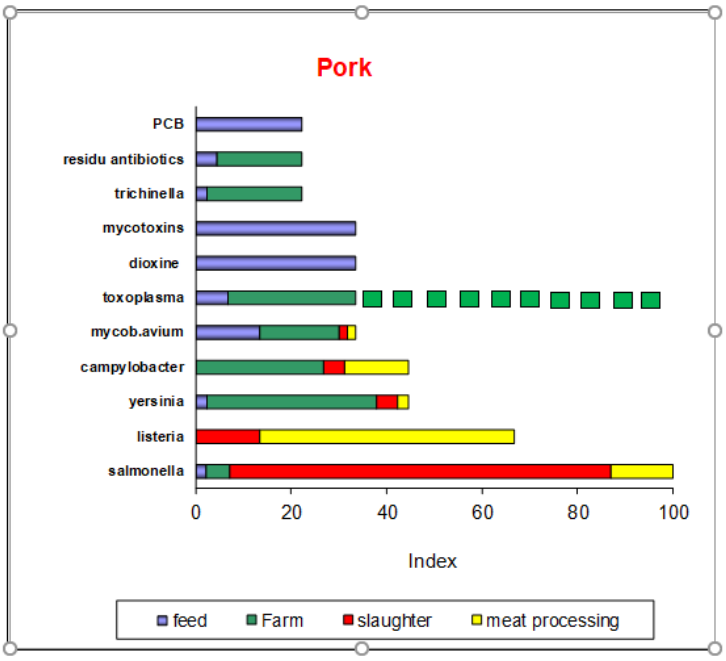


Figure 13 Estimated relative contribution in the chain to the risk for different hazards in the Supply Chain Meat Inspection of pork in the Netherlands.

To monitor and assess the performance of the farm control measures a systematic blood sample collection at abattoir level was developed. By analyzing these blood samples for the presence of antibodies against Mycobacterium avium and Toxoplasma gondii, the system is able to monitor the control at the farm phase at every delivery of animals. A feedback loop ensures this type of relevant FCI finds its way back to the farm of origin where corrective and preventive measures are taken to control the hazard.

The system is in place since several years and has been effective in controlling relevant hazards in pork production. It is an example of a risk-based approach to meat safety with a clear separation of responsibilities between private and public parties. Where private parties are responsible for implementation of control measures and managing performance levels. The competent authority supervises and audits the system. Its requirements are publicly available and is therefore easily integrated in existing pork supply chains.

In conclusion,

- The Supply Chain Meat Inspection system for pork Netherlands is one example of a risk-based meat safety assurance system
- There is a clear separation of tasks between the CA and private parties running the program
- While the solutions to control risks may differ, this offers a blueprint for how to assess risks and interventions.

8.8 Australia - balancing domestic and export requirements

8.8.1 Standards setting, official controls, and third-party schemes

Australia is a Commonwealth of states, and according to the constitution, state governments have responsibility for agriculture, health, and therefore, for food standards. The balance of responsibilities and cooperation, developed over the 120 years of federation, has resulted in a degree of uniformity, despite the individual constitutional responsibilities of state jurisdictions, through bodies and standards developed on a voluntary basis. Uniform expectations, expressed in terms of outcomes, has encouraged the development of national schemes that contribute to compliance.

Food standards, including the primary processing aspects, are embodied in the Australia New Zealand Food Standards Code developed by Food Standards Australia New Zealand (FSANZ,) a statutory authority in the Australian Government Health portfolio[5]. The standards in the Australia New Zealand Food Standards Code are legislative instruments. There are standards for poultry meat and other meat, both of which only apply to Australia[6]. State laws also govern on-farm activities and meat processing activities, so the Standard only provides statements of the outcomes to be achieved and references standards enforced by state laws.

With respect to non-poultry meats, the Australian Standard for Hygienic Production and Transportation of Meat and Meat Products for Human Consumption, AS 4696: 2007[7] applies in all States, though States differ in their administrative structures and methods of enforcement. The Standard combines the statement of outcomes expected to be achieved by each part of the Standard with prescriptive approaches to achieving the outcome. The Standard is centered around meat processing operations, but it is pivotal to the whole chain because it includes the supply and admission of animals for slaughter as well as traceability and storage, handling and transportation of meat. Significantly, the Standard states, in the preface: "Where a meat business proposes a technique different from one detailed in this Australian Standard the assessment of equivalence is to be determined by the relevant controlling authority." and then provides a conceptual framework for establishing equivalence.

For the purpose of export, importing country requirements must be met. These requirements may be thought of as either being technical or administrative. Some importing countries require additional technical requirements (for example, EU requirements concerning HGPs) and other require additional administrative requirements (for example which competent authority provides certification). For this reason, amongst others, the Australian Department of Agriculture, Water and the Environment, supervises and certifies most meat processing establishments packing product for export[8] . The system is periodically audited by the FVO, and is found to be suitable for export of product to the EU.

The need to operate a national system within a country in which responsibilities are shared based on geography, has lent itself to development of industry-wide systems to assist with

[5] http://www.foodstandards.gov.au/Pages/default.aspx
[6] https://www.foodstandards.gov.au/code/Pages/default.aspx
[7] https://www.publish.csiro.au/book/5553/
[8] https://www.agriculture.gov.au/export/controlled-goods/meat

compliance against outcome-based regulations. 3rd party compliance and verification schemes are thus an essential part of a thorough system and will be described in the following section.

In conclusion, according to the Australian experience,

- Outcomes-based regulation allows for multiple methods of compliance
- Equivalence determination provides a risk-based method of maintaining public health
- 3rd party schemes can be an efficient means of complying and demonstrating compliance
- The 3rd party schemes can be flexibly applied to new risks in a meat safety outcome

8.8.2 Schemes contributing to compliance

A critical aspect of MSAS are the health and safety of animals coming to slaughter, particularly for aspects that are not easily assessed at ante-mortem or post-mortem inspection.

In the Australian red meat (beef, sheep meat, goat meat) supply chains, the most fundamental system requirement is for identification of animals (National Livestock Identification System), on which is added requirements for managing the safety, welfare and biosecurity aspects of the animals (Livestock Production Assurance) and passing that information through the supply chain (National Vendor Declaration)

The National Livestock Identification System (NLIS) enables livestock to be traced from their property of birth to slaughter[9] . All animals are identified with an accredited NLIS tag or device from their property of birth (identified with a Property Identification Code). As animals are bought, sold and moved along the supply chain, each movement is recorded centrally on the NLIS database. Using this information, the NLIS is able to provide a life history of an animal's movements. Using NLIS is the only means of meeting the requirements of state-based legislation on recording animal movements. It is an industry owned and operated system complying with rules agreed between state jurisdictions and industry bodies.

Livestock Production Assurance (LPA) is an on-farm food safety and quality assurance accreditation program[10] . The requirements include assessing the property for risks such as persistent chemicals from contaminated sites, application of animal treatments, providing safe feed, ensuring animals are fit for travel prior to leaving the property, ensuring biosecurity, ensuring animal welfare and recording movement of animals. LPA is a voluntary accreditation and audit system, that is commercially required by most meat processors because it provides the necessary assurance of supplying animals that comply with the requirements of the Australian Standard.

The National Vendor Declaration (NVD)[11] provides food safety information about the animals being transferred from one owner to another and can only be used by an LPA-accredited animal owner. The NVD is a statutory declaration about whether animal have been fed restricted materials, by-products (anything other than fodder crops), been on a property with persistent chemical residues or areas affected by sprayed crop chemicals, received

[9] https://www.integritysystems.com.au/identification--traceability/national-livestock-identification-system/
[10] https://www.integritysystems.com.au/on-farm-assurance/livestock-product-assurance/
[11] https://www.integritysystems.com.au/on-farm-assurance/national-vendor-declaration-nvd/

hormonal growth promoters (HGPs), received recent treatment with veterinary chemicals etc. The declaration of critical food safety information allows the purchaser of animals (or the processor) to make an assessment of the food safety risks of the animals, whether additional actions (such as residue testing) are necessary, and for which markets the animal is suitable (e.g., based on use of HGPs). A paper-based system is giving way to electronic completion of declarations by sellers and transmission of data to purchasers.

There are a number of other schemes associated with feed production, use of agricultural chemicals, and operation of feedlots, saleyards, and animal transport etc. but the above systems form the basis of the assurance of red meat safety. The system is overseen by a government - industry partnership aptly named SAFEMEAT[12].

In conclusion,

- Quality Assurance schemes allow a flexible and responsive approach to meeting meat safety requirements
- Open dialogue about the operation of schemes, and verification of effective operation is still necessary
- The operation of schemes can provide opportunities for ongoing education and involvement of the whole supply chain in delivering the standard of safety required.

9. Food Safety Culture

It appears that foodborne disease and incidents are more often caused by failures of GMP's (Good Manufacturing Practices) and more rarely caused by food safety system failures. Consequently, one need to understand people's behaviours and the drivers that influence their actions and attitudes in regard to food safety. Hence, the food safety attitudes, values and beliefs shared by a group of people can be described as the company culture of food safety. It is the product of employee attitudes, beliefs and behaviours that determine the commitment to and robustness of an organization's food safety management. A FBO's food safety culture reflects how we make safe food around here in real life.

Building on this insight in September 2020, the Codex Alimentarius Commission adopted a revision of its global standard on General Principles of Food Hygiene (CXC 1-1969). The revised standard introduced the concept of food safety culture as a general principle. The food safety culture should enhance food safety by increasing the awareness and improving behaviour of employees in food establishments. It fit neatly with the development of MSAS. As this is the global standard, consumers in EU and abroad and countries to which RIBMINS countries export to would expect compliance with this principle.

Consequently, during the autumn of 2020 the EU Commission proposed to amend Regulation 852/2004 to include food safety culture as requirement of FBOs. The idea is that a food safety culture within a food business enhances food safety, by increasing the awareness and improving behaviour of employees in food businesses. The implementation of the food safety culture will take account of the nature and size of the food business. We believe this requirement is in line with and probably a prerequisite for establishing a risk-based meat safety assurance scheme or system.

[12] https://www.safemeat.com.au/

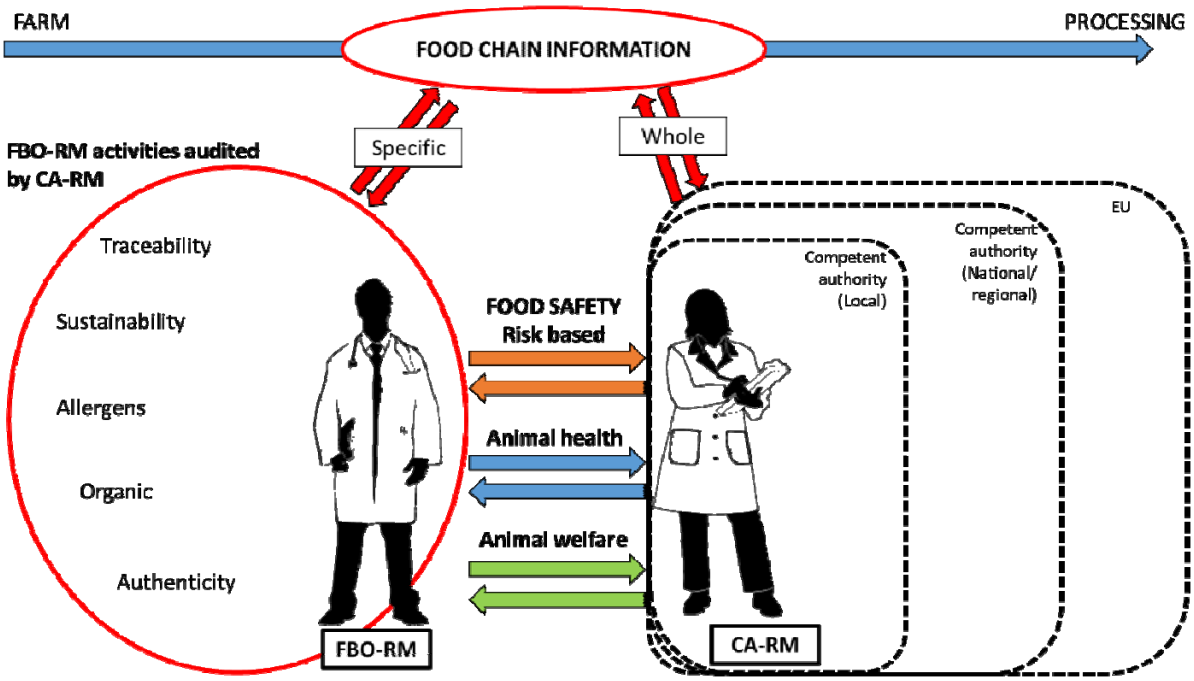
A strong and industry food safety culture is integral to success, given that industry have primary responsibility for food safety. A Food Safety Culture may be defined as the food safety attitudes, values and beliefs shared by a group of people. It is the product of employee attitudes, beliefs and behaviours that determine the commitment to and robustness of an organization's food safety management. In effect, an organization's food safety culture reflects "how we make safe food around here".

The proposed addition to the regulation will require food businesses to establish, maintain and provide evidence of an appropriate food safety culture by fulfilling the following requirements:

- commitment of the management and all employees to the safe production and distribution of food
- leadership towards the production of safe food and to engage all employees in food safety practices
- awareness of food safety hazards and of the importance of food safety and hygiene by all employees in the food business
- open and clear communication between all employees in the food business, within an activity and between consecutive activities, including communication of deviations and expectations
- availability of sufficient resources to ensure the safe and hygienic handling of food.

Clearly, this appears to be the terms of reference for the auditing of the MSAS to be done by the CA. To some extent it is also a job description for the risk manager at the FBO or rather the risk management function at the FBO. Furthermore, the FBO management's commitment shall include:

- ensuring that roles and responsibilities are clearly communicated within each activity of the food business
- maintaining the integrity of the food hygiene system when changes are planned and implemented
- verifying that controls are being performed timely and efficiently
- documentation is up to date
- ensuring that the appropriate training and supervision are in place for personnel
- ensuring compliance with relevant regulatory requirements
- encouraging continual improvement of the food safety management system of the food business, where appropriate, taking into account developments in science, technology and best practices.



The last point highlights also what we foresee as a strategy of continuous evolution of risk based MSAS within the RIBMINS member countries. It will be an obligation of both FBO and CA of the member states to facilitate this development of improved food controls.

In conclusion,

- A strong industry food safety culture is integral to success of risk based MSAS, given that industry have primary responsibility for food safety. A Food Safety Culture may be defined as the food safety attitudes, values and beliefs shared by a group of people. It is the product of employee attitudes, beliefs and behaviours that determine the commitment to and robustness of an organization's food safety management. In effect, an organization's food safety culture reflects "how we make safe food around here".
- The food safety culture requirements appear to be the terms of reference for the auditing of the MSAS to be done by the CA. It is also a job description for the risk manager or risk manager function at the FBO.

10. Discussion and synthesis

Carcass meat safety assurance will be based on collaboration between FBO and CA. The risk ranking or categorization of farms and slaughterhouses should be based on their production systems (e.g., controlled/non-controlled housing), risk-reducing performances (HEI: harmonized epidemiological indicators). One could foresee different meat inspection procedures for low-risk and high-risk incoming animals. When choosing risk mitigation measures the impact from different food safety management systems assuring hygiene and cold chain maintenance (GMP/GHP and HACCP) should be considered. The use and analyses of FCI as well as traceability of animals and meat need to be improved.

The overall pattern in Europe and globally is a move towards risk-based meat safety assurance. This has been through changes of legislation in the EU. By reducing incisions and

handling of carcasses the between carcass cross-contamination by biological hazards has been reduced. For example, Regulations (EU) 2017/625 and (EU) 2019/627 allow visual-only inspection for pigs, young domestic sheep and goats, and solipeds (with the exception of grey horses inspected for melanosis). For other animals, palpation and incisions are reduced to a few organs and parts of the carcass. Only in case of high-risk animals, when risks for human health, animal health or animal welfare are suspected, will the Official Veterinarian palpate and incise parts of the carcass (Article 24; Regulation 2019/627).

In this context of visual inspection of carcasses, novel technologies sensors and cameras coupled with artificial intelligence (AI) might help in detecting gross lesions, such as the imagine for faecal contamination, abscesses, haemorrhages and faecal contamination. This would aid in detection of pathogens and contaminants (antibiotics). Sensors could be used to better monitor chilled carcasses and indicate need for specific laboratory testing.

The current EU legal framework enables pilot or proof of concept studies in current operations as a way to test novel concepts and develop a more risk based MSAS. We do foresee many pilot and proof of concept studies assessing different approaches to meat safety assurance. It is therefore important that member states are obliged to report to each other scientific and technological progress which should be in scientific peer review literature.
Examples such pilot studies could include novel practical arrangements of meat inspection offering equivalent food safety, or novel ways division of labour in the slaughterhouse.

As a special case the incision of bovine masseter muscles for can be terminated according to the procedure in Regulation (EU) 2019/627 Article 30. The key concern is whether the procedure contributes to lowering the consumer risk. It would be very welcome if a review and assessment of changes in food safety risks of these changes in several RIBMINS participating member states of bovines there is a special procedure for risk-based adaption and simplification.

In the future, risk managers employed by FBOs and Official Veterinarians should work side by side, communicate risks and solve problems together, although with a clear division of responsibilities - risk management and auditing, respectively. This could be challenge in small or medium sized family businesses, where their meat safety assurance culture is influenced by long-lasting traditions and reduced economic resources. Could industry or collaborative solutions be found here for example joint industry guidelines that is either complied with or the FBO employs equivalent risk mitigation alternatives. The CA should then supervise the industry guidelines.

FBOs that implement private standards or 3rd party guidelines should have the effort recognized by the CA. While the regulatory burden for FBOs may not diminish when complying with private standards the different standards may offer more adapted and fit for purpose risk management. Competition between and evolution of private or 3rd party standards would be beneficial for food and meat safety. Large-scale businesses are more equivalent partners with CA and able to protect their economic interests and guarantee meat safety. In the case of vertical integration of meat supply chains from farm to fork it is important to carefully design the flow of information between all stages of the meat chain, the control points mitigating the risks best and the optimal risk management. Vertical integration along the meat chain from farm to fork tend to align the incentives of all FBOs involved in terms of food safety and profitability.

The MSAS might be embedded in quality assurance programs or schemes with multiple purposes including ensure safe meat - acceptable levels of chemical and biological hazards, control of food fraud - does the lasagna actually contain beef and not horse meat, enable tracing and tracking of provenance - is the Parma ham from Parma, ensure meat quality in the broadest sense – shelf life of meat products, ensure animal welfare, feedback to farmers meat quality and fat content, enhance sustainability by limiting food waste and losses, and improve efficiency of the food value chain. This means that the FBO's risk manager has to be able to work in a complex context with a multitude of aims and tasks. This will have implication for the required skills profiles of the risk manager at the slaughter house – some sort of team approaches seems beneficial.

This broad context of MSAS is supported by Regulation EU 2017/625 for which the scope is food safety, integrity and wholesomeness at any stage of food production, processing and distribution of food, including rules aimed at ensuring fair practices in trade and protecting consumer interests and information, and the manufacture and use of materials and articles intended to come into contact with food. The CA should perform official controls regularly, on a risk basis and with appropriate frequency, on all the sectors and in relation to all operators, activities, animals and goods governed by the EU food chain legislation. The frequency of official controls should be established by the CA having regard to the need to adjust the control effort to the risk and to the level of compliance expected in the different situations, including fraudulent or deceptive practices. We propose that 3rd party schemes, industry standards and guidelines, and vertical integration should be relevant elements for the CA to consider in this regard.

RIBMINS most important aim is to spread the MSAS culture to as many "actors" as possible, small, medium and large-scale FBOs and CA, so that new perspectives and high level of consumer protection can become a reality. In this regard fit for purpose and working results oriented (output based) will be the basic tenets. Recalling Article 14 of the General Food Law [Regulation (EC) 178/2002] food is considered unsafe if it is injurious to human health and/or unfit for human consumption. This crucial principle must be satisfied by the risk based MSAS through FBOs respecting legislation in force as well as applying new technologies and following private standards (Global Red Meat Standard, ISO 22000, FSSC, IFS, BRC).
In conclusion,

The current EU legal framework enables pilot or proof of concept studies in current operations as a way to test novel concepts and develop a more risk based MSAS.

It is therefore important that member states are obliged to report to each other scientific and technological progress which should be in scientific peer review literature. Examples of such pilot studies could include novel practical arrangements of meat inspection offering equivalent food safety, or novel ways division of labour in the slaughterhouse.

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It should be noted that maximising **cost-effectiveness** and **cost-efficiency**, together with facilitation of technological innovation, are inherent goals of future MSAS.

The modern meat safety system is: (1) risk-based (focused on the high-risk hazards with the aim of reducing the overall meat safety risk), (2) longitudinally integrated (multiple interventions or measures along the food chain are necessary to achieve required meat safety goals), and (3) flexible and dynamic (adaptable to changes while it still fulfils functional demands). The main responsibility for meat safety is now placed on food business operators (FBOs), i.e. meat producers, while the competent authorities (CAs) have advisory and auditory roles in official controls, along with their role of acting if FBOs do not comply (Blagojevic et al., 2021)

MSAS (Meat safety Assurance System): the whole system of measures in place along the meat chain (from farm to fork) aiming to guarantee consumer health.
In this report we will use EU-MSAS to define the system in place in the EU (see figure) and FBO-MSAS to define the assurance scheme in place in specific processing plant.

Private MSAS: to define private assurance systems linked to the meat chain.

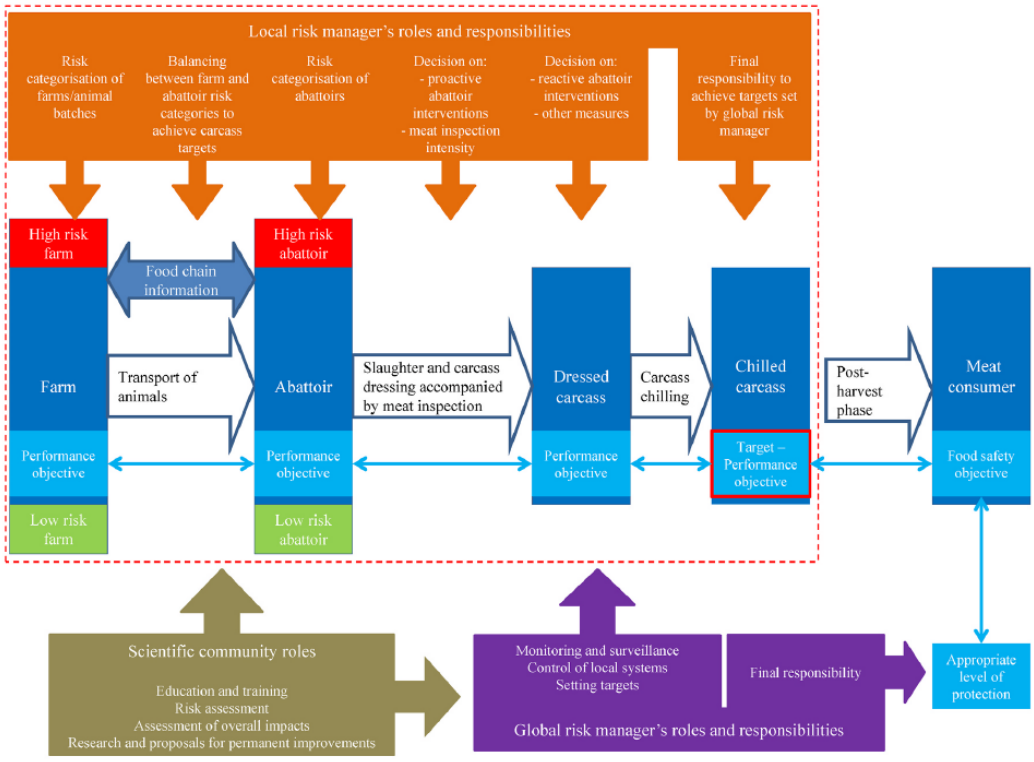

Figure: New RB-MSAS as defined by EFSA and described in Blagojevic et al. (2021).

1. CONCLUSIONS AND RECOMMENDATIONS

1.1 TOR A - To provide a systematic and detailed description of MSASs currently in place, wholly or in part, with working examples illustrating functions and outputs.

Conclusions

1 FBO-MSAS are variable and highly depends on the resource availability (size of the businesses), and ability of local CA to enforce regulation.

2 Current MSAS reserve some operations to the official veterinarians (OV), as, for example ante e post-mortem inspection. In poultry, lagomorphs and fish slaughterhouses, the situation is different allowing more space to risk management.

3 The information on priority hazards may guide the focus of MSAS. The most important meat-borne zoonoses (Salmonellosis, Campylobacteriosis, Yersiniosis, STEC infection) are asymptomatic in food-producing animals and cannot be detected at post-mortem inspection. A “farm-to-chilled carcass continuum” (EFSA, 2013) makes sense only if the health status of the animals is well known, especially for those meat-borne zoonoses which usually do not cause clinical diseases or macroscopic lesions in the infected animals. Proper control plans at farm level are lacking for the most important zoonotic agents (Salmonella in pigs; Campylobacter in poultry; STEC in cattle) with the exception of Salmonella in poultry.

4 The current meat inspection procedures do not mitigate chemical hazards. No chemical hazards are considered at high risk according to EFSA in their opinions on meat inspection. However, in Europe 1-2 major food contamination events involving chemical hazards could be foreseen annually, requiring information on the feeding on the farm, medicine and other chemicals used.

5 Farms and slaughterhouses are connected by the information provided by the so-called FCI or a declaration by the supplier, which are part of the documentation used to carry out ante-mortem inspection of animals and establish their suitability to be slaughtered for human consumption. Nevertheless, the flow of information is often ineffective and FCI are lacking several parameters, which could be crucial at slaughter (example prevalence of high-risk biological hazards in farmed animals and data on quality and safety of feed).

6 The traceability system currently in place for the beef chain is useful in case of non-compliances to track food sources and to inform consumers about meat origins, but it is not linked to other safety information.

7 The current system is mainly based on a control of different processing plants according to their ability to guarantee the safety of food products. No categorization exists according to the functional ability of slaughterhouse or meat plant to manage contaminated meat batches. As suggested by EFSA, such categorization should be very important to allow the delivering of meat batches to plant according to their risk management abilities.

8 Private assurance schemes are 2nd or 3rd party owned solution that allows a flexible and responsive approach to meeting safety requirements guaranteeing commercial advantages

over competitors. Private and or 3rd party assurance schemes deal with product characteristics such as quality, origin and trademark going beyond food safety and they inform and improve the launching and functioning of risk based MSAS. The FBOs regulatory or supervisory burden may not diminish as the 2nd and 3rd party schemes might just as onerous as the official controls.

9 Equivalence is a primary concept. Being able to provide evidence of a similar food safety outcome in different settings is fundamental to a risk-based approach in design and implementation of MSAS

10 A strong industry food safety culture is integral to success of risk-based MSAS, given that industry has primary responsibility for food safety. A Food Safety Culture may be defined as the food safety attitudes, values and beliefs shared by a group of people. It is the product of employee attitudes, beliefs and behaviours that determine the commitment to and robustness of an organization's food safety management. In effect, an organization's food safety culture reflects "how we make safe food around here".

1.2 TOR B - To provide guidance on transition from current MSASs to a “fit-for-purpose” MSAS of the future.

Recommendations

1 Small and medium sized businesses need generic FBO-MSAS or industry guidelines to enable them to achieve the same levels of protection as other FBOs. However, they should have the necessary minimal expertise to apply them.

2 The OV (CA) should be allowed to focus more on auditing and controlling the risk management as carried out in plants and less on operations like AM and PM inspection.

3 Longitudinally integrated system entails controls throughout the meat chain including farm and slaughterhouse stages. The flow of FCI should allow prioritisation, aggregation and accumulation of additional data pre-harvest, at slaughter and associated steps afterwards.

4 MSAS should also offer generic prevention of chemical hazards and support mitigation of such risks if they occur.

5 FCI effectiveness should be improved. Each meat batch should be paired with a set of essential information, available to FBOs and CAs, allowing different risk managers along the chain to properly ensure meat safety (or necessary intervention also beyond the slaughterhouse. There are technologies such as including distributed ledgers (i.e. blockchain) offering innovative advantages to facilitate data sharing and trust in data along the meat supply chain.

6 Traceability and FCI should work in a more coordinated manner to allow the tracking of meat batches along the chain and enforcing the ability of specifically manage the risk of each batch.

7 A categorization of processing plants and slaughterhouses is needed to properly deal with food safety issues identified at farm level (i.e. logistic slaughter). This should be a task for CA that could take advantage of private MSAS.

8 The private assurance schemes should not be understood as control mechanisms but rather influences to the risk management. The operation of schemes can provide opportunities for ongoing education and involvement of the whole supply chain in delivering the standard of safety required. Often these schemes are linked to food retailers' private labels thereby facilitating vertical integration of the food chain. The official controls should recognize but also supervise and audit the 2nd and 3rd party schemes if they are to replace the on-site official control. The 2nd and 3rd party schemes could rapidly promote the spread of best practices in the food chain. The Earned Recognition Schemes could be important elements of future risk-based MSAS.

9 Equivalence between private MSAS requirements and official controls is important, however, does not suffice for integration. While equivalence is vital, differences "in the purpose, assessment focus and approach" by MSAS mean that equivalence does not equal the ability to function as replacements for official controls. A critical point is the reliability of private schemes, to say more completely, in terms of deliver in practice may be seen as a particular challenge, resulting from MSAS inability to enforce compliance like official competent authorities do.

10 It is necessary to develop methodology for standardisation assessment of effectiveness of MSAS. Such methodology may integrate assessment on the equivalence with the official control, effectiveness of controls, reliability and performance of different MSAS' and /or their components.

11 CA, FBOs, and private scheme should work together to the benefit of a food safety culture.

1.3 TOR C - To suggest outlines for risk ranking that could aid when designing or adjusting the MSAS.

Conclusions

1 EFSA identified several hazards for different slaughtered species: pig (*Salmonella* sp, *Yersinia enterocolitica*, *Toxoplasma gondii* and *Trichinella)*, poultry (*Salmonella, Campylobacter* and ESBL-AmpC producing *E. coli*), beef (Salmonella and STEC). Risk ranking is a helpful tool for prioritising and to enable a risk-based meat safety assurance. The risk ranking at regional level should target identified hazards by setting Food performance criteria (EFSA proposed to establish performance targets on chilled carcasses for both *Salmonella* and STEC in beef). The EU has established performance objectives (prevalence targets) for *Salmonella* flocks and for *Campylobacter* on chilled (poultry) carcasses (process hygiene criteria). The community, national and regional risk assessments will be informed by the ongoing monitoring and surveillance activities. These should be done under the supervision of the CA.

2 The FAO guidance on risk ranking and prioritisation based on multicriteria are also useful source of information and advice.

3 Emergent meat borne hazards (*Taenia solium* in Greece, HEV in pigs), deserve more attention and show us how a local level risk based system is required to address specific risks.

4 On-site risk based management activities are often fixed in HACCP procedure and not frequently updated (especially in small and medium plants) according to EU and national risk rankings and evaluations.

Recommendations

1 Risk ranking at EU level need to be regularly updated based on CA data. A more complete set of FCI can help in collecting relevant information along the food chain.

2 Besides EU risk ranking, risk should be addressed also at national /regional level allowing specific interventions against food safety issue within the territory.

3 On-site risk based management activities should be based should address EU and national/regional identified risk focusing on more probable on according to FCI.

1.4 TOR D - To develop the competency profiles for the risk managers. We foresee at least two profiles one for those responsible for the MSAS at the food businesses and one for the official controls.

Conclusions

1 A risk-based MSAS requires real time management of risks from the identified hazards. Data availability and resource constraints will make quantitative risk assessments difficult on the FBO or slaughterhouse level. Risk ranking could be a practical tool for the FBO and as input in the MSAS.

2 FBO risk manager and CA risk manager are two separate professional figure with overlapping competencies but different tasks. A collaboration between them is needed but confusion between tasks should be avoided.

3 Risk manager (RM) is a professional working for competent authority enforce the regulation on meat safety and animal welfare using official controls to verify that FBOs properly deals with food safety issues. The RM periodically audit specific parts of the FBO MSAS in place and collect relevant information for national CA. That RM carries out AM and PM and certifies meat fitness for human consumption.

4 Risk manager working for FBO should deal with meat safety issues on behalf of the owner. He additionally deals with animal welfare and all other quality issues linked to the wholesomeness of meat.

5 Second and 3rd party assurance scheme are parallel MSAS not or little taken into account by CA that enforce meat safety and quality by giving a competitive advantage to subscribers. They deal more with pre-requisites and has check-list to assess FBO compliance.

Recommendations

1 A regular complete and effective flow of relevant FCI is needed to allow a risk based MSAS at plant level.

2 Two roles are foreseen for veterinarians in the future MSAS: one as risk manager of the MSAS employed by the FBO, and another one as official veterinarian auditing the MSAS. The roles of risk managers working for CA and FBO should be clearly separated. Furthermore, small and medium facilities need a risk manager with a sufficient expertise to deal with incoming risks. Risk manager working for CA should not supply the gaps in FBO organization. There is a need for collaborative industry solutions for the MSAS serving small and medium sized slaughterhouses. The potential for telemedicine should be explored for use in small slaughterhouses.

3 Risk manager working for competent authority should guarantee the enforcing of regulation, the identification of unexpected hazards, and should assist FBO risk manager in dealing with incoming risks (known due to EU or national risk rankings or FCI). He should be less engaged in AM and PM activities and more on risk management. The slaughterhouse is a key point for monitoring the magnitude of hazards entering the meat food chain as well as a privileged epidemiological point of observation. He should enforce the flow of FCI also communicating with previous operators (i.e farmers).

4 Risk manager working for FBO should be able to deal with incoming risk, in collaboration when needed, with the CA. He should know that food safety and animal welfare issues are the starting point of a good assurance scheme and that the other quality attributes can be guarantee without taking over safety. He should receive regular training to understand risk rankings and updates in the epidemiological situation.

5 Private 2nd or 3rd party assurance scheme can be helpful for risk manager in order to be complaint with regulatory and non-regulatory indications. They can assist CA allowing a reduction of controls/audits frequency. CA should evaluate their enforcement as well as the equivalence with EU-MSAS

11. Glossary

The terminology used is truly important to avoid confusion and spurious disagreements. When developing a novel MSAS a joint terminology will be one of the critical stumbling blocks for successful completion of our tasks. We decided therefore to include all terms that caused the WG confusion or is likely to cause confusion amongst readers.

A classic example is the difference between monitoring and surveillance where different definitions abound. A common description is that monitoring is focused on populations and no actions are foreseen for those with positive test results. Surveillance is focused either on individuals or on populations and actions are foreseen for those testing positive.

Assessment: A process of determining the presence or absence of a certain condition or component, or the degree to which a condition is fulfilled. *(Source: CAC/GL 91-2017)*
Accreditation: third party attestation related to a conformity assessment body conveying formal demonstration of its competence to carry out specific tasks. *(Source: ISO/IEC 17000:2004)*
Accreditation body: authoritative body that performs accreditation *(Source: ISO/IEC 17000:2004)*
Assurance: Positive declaration intended to give confidence. *(Source: Oxford English dictionary).*
Attestation: issue of a statement, based on a decision following review that fulfilment of specified requirements has been demonstrated. *(Source: ISO/IEC 17000:2004)*
Audit: is a systematic and functionally independent examination to determine whether activities and related results comply with planned objectives. *(Source: CAC/GL 20-1995)* a systematic and independent examination to determine whether activities and the related results of such activities comply with planned arrangements and whether these arrangements are applied effectively and are suitable to achieve the objectives (*Source*: EU Regulation 2017/625)
Certification body: A provider of certification services, accredited by a nationally recognised accreditation body. *(Source: ISO/IEC 17000:2004)*
Conformity assessment: demonstration that specified requirements relating to a product, process, system, person or body are fulfilled. *(Source: ISO/IEC 17000:2004)*
Credibility (dictionary): The quality of being trusted and believed in. *(Source: Oxford English dictionary)*
Governance: the processes and arrangements through which organisations are administered, in particular how they are directed, controlled and led including the way management systems are structured and separated to avoid potential conflicts.(*Source: new*)
Inspection: is the examination of food or systems for control of food, raw materials, processing, and distribution including in-process and finished product testing, in order to verify that they conform to requirements. *(Source: CAC/GL 20-1995)* inspection" means the examination of establishments, of animals and food, and the processing thereof, of food businesses, and their management and production systems, including documents, finished product testing and feeding practices, and of the origin and destination of production inputs and outputs, in order to verify compliance with the legal requirements in all cases (Source CE Regulation 854/2004);
Integrity (dictionary): The quality of being accurate and reliable. (Source: new)

Procedure: specified way to carry out an activity or a process. *(Source: ISO/IEC 17000:2004)*
Review: verification of the suitability, adequacy and effectiveness of selection and determination activities, and the results of these activities, with regard to fulfilment of **specified requirements.** *(Source: ISO/IEC 17000:2004)*
Specified requirement: need or expectation that is stated. *(Source: ISO/IEC 17000:2004)*
vTPA Standard: specified requirements contained in the vTPA programme. (*Source: new*)
Voluntary Third-Party Assurance Programme: An autonomous scheme comprising of the ownership of a standard that may utilise national/international requirements; a governance structure for certification and conformity assessment that provides for periodic onsite audits for FBO operations for compliance with the standard, and in which FBO participation is voluntary. (*Source: new*)
vTPA Owner: Person or organisation responsible for developing and maintaining a specific vTPA programme. (*Source: Adapted from ISO IEC 17065*)

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