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# How do food safety tools support the animal origin food supply chain?

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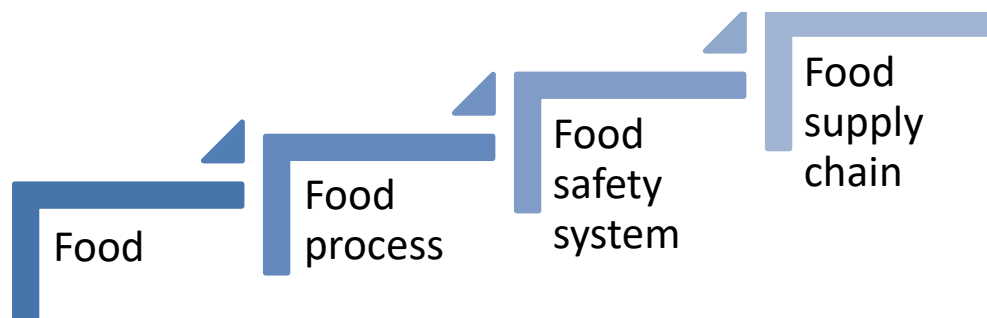
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**Abstract.** This study gives an overview of food safety tools that have been developed recently through the perspective of the animal origin food supply chain. It introduced some expected food safety legal issues, new technological outbreaks, food safety culture outlined in latest versions of food safety management system standards and tools applicable for the entire supply chains. Finally, the paper briefly shows some incentives associated with food safety and Covid-19 as well as the role of UN Sustainable Development Goals in animal origin food.

## 1. Introduction

Food safety as a concept intertwines with two ends of the pipeline – safety of food (as a product) and fulfillment / management of various food safety requirements from the farm to the fork. General food law outlines that “in order to ensure the safety of food, it is necessary to consider all aspects of the food production chain as a continuum from and including primary production and the production of animal feed up to and including sale or supply of food to the consumer because each element may have a potential impact on food safety.” [1]. On the other hand, international food safety management system (FSMS) standards define food safety as assurance that food will not cause any (health) harm to the consumer when prepared and/or consumed according to its intended use [2, 3]. Based on the above, four main dimensions of food safety upscaled from food to the food supply chain can be recognized, Figure 1.



**Figure 1.** Four food safety dimensions



The aim of this paper is to provide an insight into food safety tools associated with each of the four dimensions that have been developed recently through the perspective of the animal origin food supply chain. In parallel, it provides an “out of the box” perspective of food safety in terms of the on-going pandemic caused by the coronavirus SARS-Cov-2, Covid-19 and UN Sustainable Development Goals.

## **2. Animal origin food**

It is well-known that production of animal origin food is subject to high levels of (self)control and (self) inspection, as animals and animal origin food can transmit a variety of food borne diseases to consumers [4]. In that sense, a vast set of regulations is put into force to control safety of meat and dairy products, mainly focused on controlling maximal allowable values of potential chemical and microbial hazards, including the presence of toxic elements in food packaging. The microbiological criteria providing guidance on the acceptability of foodstuffs, is a good example [5]. Another issue of interest mainly associated with meat is its cancerogenic risk as outlined by the International Agency for Research on Cancer that analyzed 800+ epidemiological studies associating 15+ types of cancer with consumption of meat and meat products [6]. This caused many pro and con campaigns related to meat in human diets, where the cancerogenic and environmental issues were opposed to nutritional advantages of meat.

As healthy diets are in focus during the last decade, the pursuit of dietary health benefits led to development of new/modified food labels covering various nutritional and health claims. However, this raised another challenge as investigated in a study from 28 countries revealing three main variations: different labeling of various nutrition/health claims; modifications in authorization procedures and different levels of using scientific opinion [7]. Finally, an interesting response to the aflatoxin crisis that affects not only maize but also the milk supply chain was to implement an aflatoxin-safe certification to enable consumers’ healthy food choices [8].

## **3. Food processes in animal origin food companies**

When it comes to technological issues associated with the companies producing animal origin food, two development directions arise: (i) usage of non-thermal food processing technologies and (ii) implementation of Food Industry 4.0.

Non-thermal food processing technologies have different types of action, depending of the source of energy transfer and can be divided as: (a) technologies based on mechanical action; (b) electro-magnetic field-based technologies and (c) pressure-based technologies [9]. The main advantage of these new processing technologies is assurance of safety of the products [10]. Research is mainly focused on microbial inactivation, food safety and preservation while retaining quality of the obtained products. Use of these technologies, besides achieving microbial inactivation [11-13], provides some nutritional improvements [14-16] due to decreased processing time and prevention of negative effects of heat.

Examples are the use of ultrasonic power in an attempt to examine the oxidation of beef proteins [17] or the use of ultrasound in reducing the microbial load in milk [18]. However, the use of different types of non-thermal food processing technologies due to their novelty and different technological readiness levels, meaning they are not fully covered by (food) legislation. An example of change is from Health Canada, which analyzed a great number of ready-to-eat meats, raw meats, and egg products processed with high pressure processing and concluded that such foods should no longer be considered as novel foods [19].

(Food) Industry 4.0 is recognized as a combination of internet-oriented technologies and smart systems enabling advanced communication between each part of the system and improved human-machine interaction systems [20]. Further applications are expected in terms of implementing smart sensors, artificial intelligence and big data into food industry [21]. There are cases of partial implementation of Food Industry 4.0, like in maintaining the cold chain using IoT temperature sensors [22]. It is well known that the cold chain is vital in keeping meat safe, as low temperatures inhibit growth of microorganisms [23].

#### **4. Food safety systems in animal origin food companies**

Although there are many FSMS standards, the ones recognized by the Global Food Safety Initiative as most appropriate for the animal origin food supply chain are FSSC 22000, BRC and IFS [24]. They consist of three basic parts: prerequisite programs (PRPs), hazard analysis and critical control points (HACCP) and management requirements needed to upscale HACCP to a food safety management tool. Serbian meat and dairy companies prefer ISO 22000 as opposed to IFS/BRC [25, 26]. Their outcome in implemented FSMS is overseen in increased safety of food and higher levels of hygiene in establishments with an operative HACCP in place. Once HACCP became mandatory in meat establishments, it directly improved all process hygiene indicators, outlined in significant reductions of hygiene indicator organisms on all types of meat contact surfaces [27]. Another interesting perspective has been observed in animal origin food companies regarding quality management systems, where most of the companies interpret food quality as having the same importance as food safety [28].

Food safety culture is a new perspective of FSMS, where BRC is one of the international standards that promotes this new requirement. It is defined as attitudes, values and/or beliefs at site associated with the importance of food safety [3]. In parallel, scholars outlined five components necessary to assess this food safety perspective as follows: leadership, communication, commitment, resources and risk awareness [29]. A study performed in Central and Eastern Europe shows that bigger companies have higher levels of food safety culture as opposed to small companies [30, 31]. The same study confirmed that country of origin (EU vs. non-EU) is the greatest influencer in adopting food safety culture, mainly because the EU is putting into force more extensive FS legislation. Finally, this study identified that companies operating in the animal origin sector have a lower level of FSMS in place, as opposed to similar studies in Europe where FSMS in this sector, due to food safety risks, were on a higher level [32].

#### **5. Animal origin food supply chains**

When food safety is elevated to a supply chain perspective, different tools are developed in analyzing various food safety risks. One tool is the concept of food safety objectives, developed to prevent or minimize exposure of the consumer to any type of food hazard [33]. It employs techniques, or models applied from the farm to the fork considering all kinds of variations and changes associated with ingredients, process steps, distribution, and final food preparation (at home or in food service establishments). It provides a value, such as the appropriate level of health protection, whereby it calculates the maximum frequency and/or concentration of a food safety hazard in food at time of consumption with the aim of achieving public health goal(s) [34].

A second tool is to perform an exposure assessment. This is a quantitative measurement of health risks associated with a food hazard, whereby it is necessary to calculate occurrence of a specified hazard in food on one hand and to analyze consumption of food in a population based on consumption surveys on the other hand [35]. This has been used in the case of aflatoxin in milk and dairy products, where the results obtained become usable for all stakeholders in the dairy chain continuum for their decision making and/or developing risk mitigation strategies [36, 37].

#### **6. Out of the box**

Since the World Health Organization (WHO) announced that Covid-19 is a public health emergency of international concern [38], all aspects of life, including food supplies have been affected. To help food companies, the WHO developed a guidance document supporting scientific belief at the time of publishing [39]. As coronaviruses do not have the potential to survive on food products or food packaging [40], the European Food Safety Authority specified that food should not be considered as a risk and/or transmission route [41]. In order to challenge food safety during the pandemic, an international survey assessed food companies' responses to the pandemic [42]. Results of interest highlight that maturity of a FSMS was correlated with the response to the pandemic, where companies operating in the animal origin food companies were identified as companies having only basic but still effective food safety, with staff awareness and hygiene as the most important PRPs.

Another dimension of interest encompasses the 17 Sustainable Development Goals (SDGs) adopted by the United Nations within its 2030 Agenda [43]. Eight out of 17 SDGs are correlated with food and food systems [44], where SDG12 'Responsible consumption and production' and SDG 13 'Climate action' are goals highly associated with animal origin food. The livestock sector with its environmental impacts uses natural resources and causes environmental pollution [45] but also affects climate change [46, 47]. Upscaling to the animal origin supply chain, climate change effects occur at farms [48], affect meat and dairy production [49, 50] and end at households [51, 52].

As a result of these environmental impacts, the Food and Agriculture Organization defined sustainable diets as “diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations” [53]. However, the pressure on changing dietary habits as a response to climate change affected by meat and other animal origin food, is still more theoretical than observed in every-day life. This kind of research focuses on analyzing effects of meat/dairy replacements, with plant-based substitutes. Such models reveal the potential of changing eating patterns and decreasing environmental impacts [54]. Although there are diets that exclude consumption of animal origin food such as veganism, raw foodism or fruitarianism, still a large majority of the human population eat (safe) animal origin food regularly or occasionally [48].

## 7. Conclusion

The entire animal origin supply chain is recognized as a sector directly or indirectly involved in the majority of food safety issues. Great efforts and developments are observed in all parts of the supply chain, downscaled to meat/dairy products and/or upscaled to the entire supply chain. In spite of more demanding requirements, required by new challenges such as Covid-19 and UN Sustainable Development Goals, this sector still manages to deliver safe food to consumers all around the world.

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