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Current Opinion in Food Science

Novel approaches for food safety management and communication

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Abstract

The current safety and quality controls in the food chain are lacking or inadequately applied and fail to prevent microbial and/or chemical contamination of food products, which leads to reduced confidence among consumers.On the other hand to meet market demands food business operators (producers, retailers, resellers) and regulators *need* to develop and apply structured quality and safety assurance systems based on thorough risk analysis and prevention, through monitoring, recording and controlling of critical parameters covering the entire product's life cycle.However the production, supply, and processing sectors of the food chain are fragmented and this lack of cohesion results in a failure to adopt new and innovative technologies, products and processes.The potential of using information technologies, for example, data storage, communication, cloud, in tandem with data science, for example, data mining, pattern recognition, uncertainty modelling, artificial intelligence, etc., through the whole food chain including processing within the food industry, retailers and even consumers, will provide stakeholders with novel tools regarding the implementation of a more efficient food safety management system.

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Current Opinion in Food Science 2016, **12**:13–20

This review comes from a themed issue on **Food safety**

Edited by **Konstantinos Koutsomanis**

For a complete overview see the Issue and the Editorial

Available online 25th June 2016

http://dx.doi.org/10.1016/j.cofs.2016.06.005

Introduction

At the dawn of the 21st century, the agro-food industry is facing the following main challenges: first, having enough to eat (*Food Security*) and second, ensure that it is safe to eat (*Food Safety*). These objectives should be realized not only in an environment of tremendous technological progress and evolution of consumers' life-styles, but also in economic terms, in which the food industry is called to operate under seemingly contradictory market demands. Food industry marketers perceive that consumers prefer foods that are convenient; fresh (minimally-processed and packaged); all natural — with no preservatives (the so-called 'clean label'); without negative effects (i.e., foods low in fat, salt, and sugar); and healthy. These are also affected by recently emerged issues such as climatic changes, financial crisis and breakthrough on information technologies.

Regarding *Food Safety* along the food chain, it is well known to be a shared responsibility among *Food Business Operators*, *Authorities* and *Consumers* [1]. Thus, food business operators are challenged to combine requirements from different stakeholders, such as government, retailers, while the international resolutions of the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) in 1995 [2], recognized public health risk as the *only* basis for restrictions of international trade in food, into the food industry. However, within the food chain from farm to consumer, food commodities may be exposed to multiple hazards that may cause physical, biological or chemical contamination to food and consequently increase the risk of consumption of contaminated food. These risks, for example, pathogenic bacteria [3], mycotoxins [4] biogenic amines [5] or possible carcinogenic compounds such as caramel colours [6], have created mistrust of governments and industry by the European consumer that is threatening to become a long-term problem.

Food waste for example due to variation and misapplication of date labelling and misuse, for example, in the case of marine resources, has been reported [7,8] to be probably the greatest problem concerning food security; indeed roughly 1/3 of food produced for human consumption is lost or wasted globally and within the EU more than 100 million tonnes of food are wasted annually [European Community; Food Waste [9]]. Food spoilage mainly due to microbial activity [10] is one of the most significant threats to food security. Thus minimization of food loss, as well as assurance of quality and safety [11] can be considered as the ultimate goal for the food industry.

To remedy this, the food industry and other stakeholders (e.g., competent authorities, retailers) have to provide increased vigilance with regard to food safety and quality

issues. Consumers need to be and feel reassured that food industries, as well as food authorities, are taking extra measures to guarantee the safety of foods.

The objectives set out in the White Paper on Food Safety [1] dealt with first, improvement of the efficiency and coherence of the EU food legislation, particularly in the area of food safety, second, restoring consumer confidence by the above measures and improving the quality of information available to consumers, and third, extending the scope of the EU food regulation by developing an EU-wide nutrition policy. To achieve these objectives in the area of food safety, a number of guiding principles has been applied by authorities and food organizations, namely first, adoption of the precautionary principle, second, extending the scope of food safety regulation across the entire food chain from 'farm to fork' including, for example relevant controls on animal feed, third, attribution of primary responsibility for safe food production to industry producers and suppliers within the context of the EU legislation, fourth, setting out clear responsibilities for public bodies by defining standards for the food industry to meet and monitor industry compliance, and fifth, establishing traceability as a major responsibility in food production and a prerequisite to both food safety and effective consumer choice.

Current food safety management system

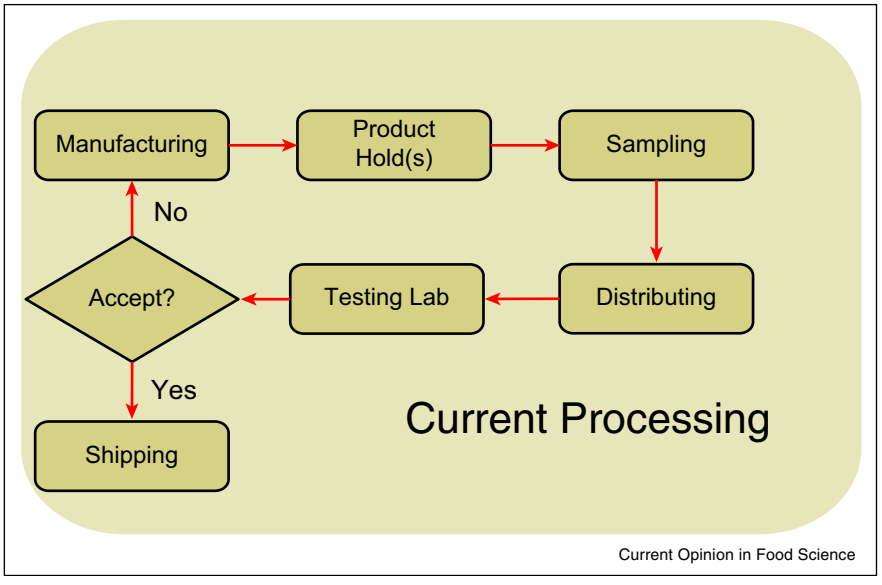
Nowadays a wide range of audits and inspections in which chemical and microbiological analyses has been proposed to evaluate the quality or safety of raw or processed materials and food products [12,13,14••]. Currently, food safety relies heavily on regulatory inspection and sampling regimes [14••]. Indeed the current food safety management system, although largely based on good design of processes, products and procedures, end or finished product testing (analyzed for certain hazards), is considered to be the control measure of the production process (Figure 1). This is evident in the case of microbiological food safety where specific microbiological analyses should be followed.

These microbiological analyses can be implemented with conventional microbiology (e.g., colony counting methods) or molecular based techniques that are considered more reliable and accurate [15–20]. Chemical analyses are also used to monitor safety and quality of foods. These analyses either microbiological or chemical (e.g. for chemical hazards) have certain disadvantages, as they are first, time-consuming providing retrospective results, second, costly, third, few require high-tech molecular tools and thus highly trained personnel, and fourth, usually destructive to test products, limiting thus their potential to be used on-, in- or at-line [21–23].

Furthermore, in the case of molecular tools, results may be misleading, as these techniques are focused so far on pathogenic rather than specific groups of the microbial association, which contribute to spoilage depending on storage and packaging conditions [16,17,19]. Molecular approaches are also costly, as high-tech instruments are required. In addition, due to the complexity of molecular techniques, the number of verified samples/measurements in many cases is severely limited.

It is evident that end-product analyses (testing) provide only very limited information on the safety status of a food,

Figure 1



Current testing and controlling of food safety implemented by the food industry.