Trends in food safety management

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Introduction

A dramatic increase in the number of incidents related to food safety in recent years is of increasing concern and is driving a paradigm shift in the way that food safety is managed. Regulatory efforts internationally have been focussed on the use of risk assessment tools to drive food policy and standards. While industry is obviously also concerned with the public health safety of its products, it must also manage the business risk to its brands, which may be adversely affected by a food safety concern even when a clear public health risk has not been established.

Operating in a market where perception is reality

When it comes to food safety in the market place, perception is reality. In order to respond to and effectively manage both real and perceived public health risks, it is important that there is an effective, proactive framework of risk communication between industry, government and consumers. Food safety issues, whether concerned with microbial contamination, chemical hazards or allergens, are complex in nature and require effective management and control measures to be applied across the value chain. Taking allergens such as peanuts as an example, effective management not only requires prevention of cross contamination during production and manufacture but also traceability during distribution, labelling on retail packaging and education of food service personnel and consumers.

In the case of chemical hazards, new sensitive analytical techniques are now able to detect contaminants at much lower levels than before, sometimes raising questions about the public health implications of chemicals that have undoubtedly been present in foods for many years. Examples include acrylamide and furan, which are currently being assessed for public health safety internationally. There is concern about the increasing complexity of chemical contamination due to the increase in global sourcing of ingredients and the use of novel packaging materials and formats.

Microbial hazards are usually more directly related to acute food-borne illness and hence have been the main target for developments in new risk assessment and management techniques. Dealing with microbiological hazards is complicated, not only by the dynamic nature of the hazard that may increase or decrease during processing and storage of the product, but also the ability of microorganisms to adapt to change.

Despite some reductions in the US [1], the incidence of food-borne illness is still increasing globally. The rapid globalisation of the food processing and retailing industries, consumer demand for more natural and more convenient products and an overall increase in the susceptibility of the population are believed to be the most important factors that have led to fundamental changes in the nature of food-borne disease itself.

Food safety and international trade

The safety of foods in international trade is governed by the World Trade Organization (WTO)/ Sanitary and Phytosanitary (SPS) Agreement, which recognises that governments have the right to reject imported foods when the health of the population is endangered. The criteria used to determine whether a food should be considered safe should be clearly conveyed to the exporting country and should be scientifically justifiable.

In order to achieve this, the term 'appropriate level of protection' has been used, which is defined as *"the level of protection deemed appropriate by the Member (country) establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory"*. Traditionally, this has been defined in terms of having a chemical or microbial risk *"as low as reasonable"*.

This definition has caused great difficulties for a number of reasons. Although trade is becoming increasingly global, the technological capabilities of different countries, and even different companies within the same country, remain very different. Also, the idea of what is considered *"reasonable"* differs from country to country; acceptable risk is culturally defined.

The food safety objective

Developments in the areas of predictive modelling and risk assessment now offer the potential to link exposure to a microbial hazard to the likely number of cases of illness in the population and are driving new risk management approaches based on the concept of food safety objectives (FSOs)[2]. Although quantitative aspects of the scheme are still being advanced, the framework will facilitate transparent communication of the food safety responsibilities of the different stakeholders across the food chain.

The appropriate level of protection (ALOP), as derived from a microbiological risk assessment (MRA), is typically expressed in terms relevant to public health, e.g. as a number of cases per 100,000 population. Whilst this serves a purpose when informing the public, especially when communicating a desired reduction in disease, the ALOP is not a useful measure in the further implementation of food safety measures at, e.g. the level of food control/ inspection or food production.

The FSO concept aims to translate public health risk into a definable goal: *"a specified maximum frequency and/or concentration of a [microbiological] hazard in a food at the time of consumption, which is deemed to provide an appropriate level of health protection."*

The approach enables the food industry to meet a specific FSO by the application of the principles of Good Hygienic Practice (GHP), Hazard Analysis Critical Control Point (HACCP) systems, performance criteria, process/product criteria and/or acceptance criteria. It provides a scientific basis that allows industry to select and implement measures of hazard control for a specific food or food operation. It should enable regulators to better develop and implement inspection procedures to assess the adequacy of the control measures implemented by industry, and to quantify the equivalence of inspection procedures in different countries. Thus, the practical value of using the FSO concept is that it offers flexibility of operation; it does not prescribe how an operation achieves compliance – it defines the goal (Figure 1).

In recognition of the need to be able to express the level of a hazard at different points in the value chain, the term performance objective (PO) has been defined as: *"the frequency and/or concentration of a hazard in a food at a specified step in the food chain before the time of consumption that provides or contributes to an FSO or ALOP, as applicable"*[3].

From the information provided in an FSO, regulatory authorities and food operators can select appropriate control measures to achieve the intended safe levels of pathogens. A control measure is *"any action and activity that can be used to prevent or eliminate a food safety hazard or reduce it to an acceptable level"*. One or more control measures may be necessary at each stage along the food chain to assure a food is safe when consumed. In the design of control measures, it is necessary to establish what needs to be achieved, the performance criterion and how it will be achieved – the process criteria and product criteria.

When designing and controlling food operations, it is necessary to consider pathogen contamination, destruction, survival, growth and possible recontamination. Consideration must be given to the subsequent conditions to which the food is likely to be exposed, including further processing and potential abuse (time, temperature, cross-contamination) during storage, distribution and preparation for use. The ability of those in control of foods at each stage in the food chain to prevent, eliminate or reduce food safety hazards varies with the type of food and the effectiveness of available technology.

A performance criterion is the required outcome of one or more control measures at a step or combination of steps that contribute to assuring the safety of a food. When establishing performance criteria, account must be taken of the initial levels of the hazard and changes of the hazard during production, processing, distribution, storage, preparation and use. An example of a performance criterion is a 6 log kill of salmonellae when cooking ground beef.

Process criteria are the control parameters (e.g. time, temperature, pH,

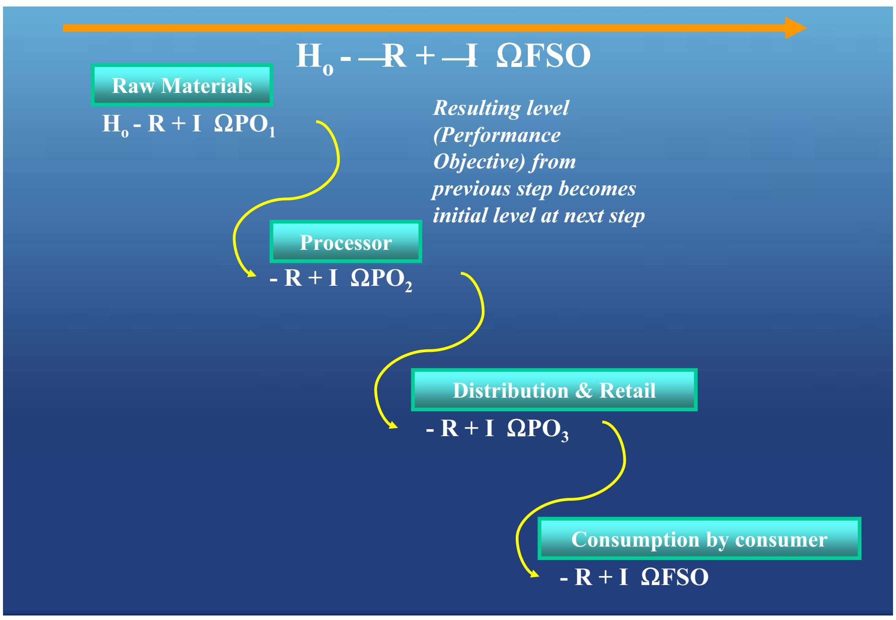

Figure 1. Example of the use of different control measures to achieve a given FSO.

water activity, a_w) at a step, or combination of steps, that can be applied to achieve a performance criterion. For example, the control parameters for milk pasteurisation in the USA are 71.70C for 15 sec. This combination of temperature and time will assure the destruction of *Coxiella burnetii*, as well as other nonspore-forming pathogens that are known to occur in raw milk.

Product criteria consist of parameters that are used to prevent unacceptable multiplication of microorganisms in foods. Microbial growth is dependent on the composition and environment of the food. Consequently, pH, water activity, temperature, gas atmosphere etc. have an influence on the safety of particular foods. For example, it may be necessary for a food to have a certain pH (e.g. pH 4.6 or below) or a_w (e.g. 0.86 or below) to ensure that it will meet an FSO for a pathogen, for which growth in the product must be limited (e.g. *C. botulinum, Staph. aureus* or *L. monocytogenes*).

When establishing performance criteria, consideration must be given to the initial level of a hazard and the changes which may occur during production, distribution, storage, preparation and use of a product. A performance criterion is preferably less but at least equal to the FSO and can be expressed by the following equation[1]:

$$H_0 - \Sigma R + \Sigma I \leq FSO$$

Where:

FSO	*Food safety objective*
H0	*Initial level of the hazard*
ΣR	*Total (cumulative) reduction of the hazard*
ΣI	*Total (cumulative) increase of the hazard*

FSO, H0, R and I are expressed in $\log_{10}$ units.

It should be recognised that the parameters that may be used in the above equation are point estimates, whereas, in practice, they will have a distribution of values associated with them. If data exist for the variance associated with the different parameters, then the underlying probability distributions may be established using an approach similar to that in risk assessment.

Example

In the example (Figures 2 & 3), Szabo *et al.*[4] worked with a commercial operation to evaluate the effectiveness of two antimicrobial washing agents (sodium hypochlorite, hydrogen peroxide and peroxyacetic acid mixture) against *L. monocytogenes* under simulated fresh pre-cut washing conditions and evaluated the growth potential of this pathogen on the product when packaged in a gas permeable film and stored at either 4^0 or 8^0C for 14 days. The results were used to demonstrate how the commercial operation could meet the FSO for *L. monocytogenes* in fresh pre-cut lettuce by the application of performance, process and microbiological criteria.

Relationship to microbiological criteria

Microbiological criteria differ in function and content from FSOs. However, occasionally the limit in a criterion is the same as a FSO or a performance criterion as, for instance, in the case of the FSO for *L. monocytogenes* in a ready-to-eat product. A FSO will normally not prescribe a sampling plan. For microbiological criteria, it is essential that such a plan is developed, because that will assist in achieving the transparency and equivalence.

The FSO states the level of a hazard at the moment of consumption; this is normally not the point in the food chain where samples are taken and tested for the frequency and/or the concentration of a pathogen. Therefore, microbiological criteria have to be related to other points in the food chain, i.e. to performance objective. The character of this relationship will depend on whether the level or concentration of a certain microorganism or a group of certain microorganisms (indicators) are measurable or not.

Benefits for industry and regulators

Setting an FSO by risk managers must take into account a number of societal

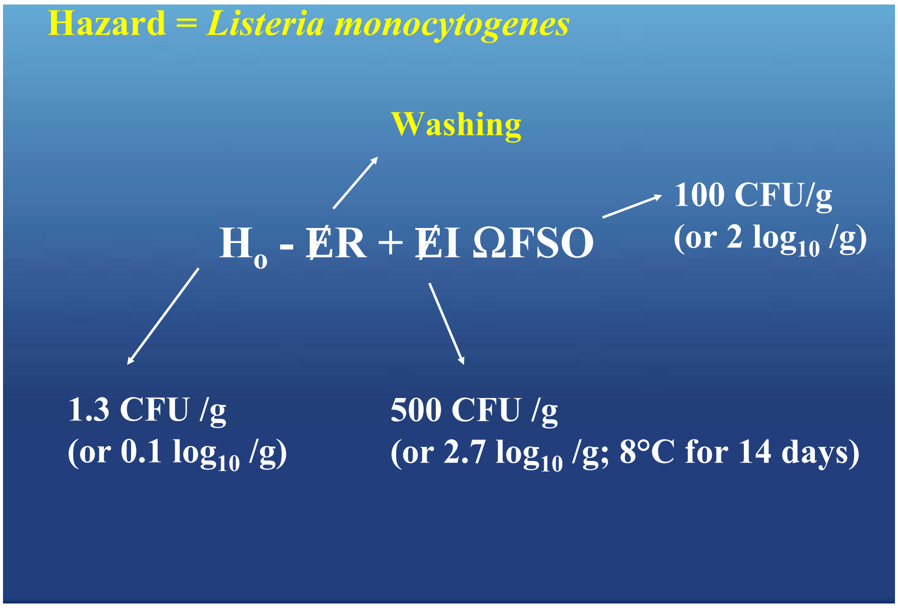

Figure 2. Applying a hypothetical FSO for *Listeria monocytogenes* in fresh pre-cut lettuce via performance and process criteria[4].

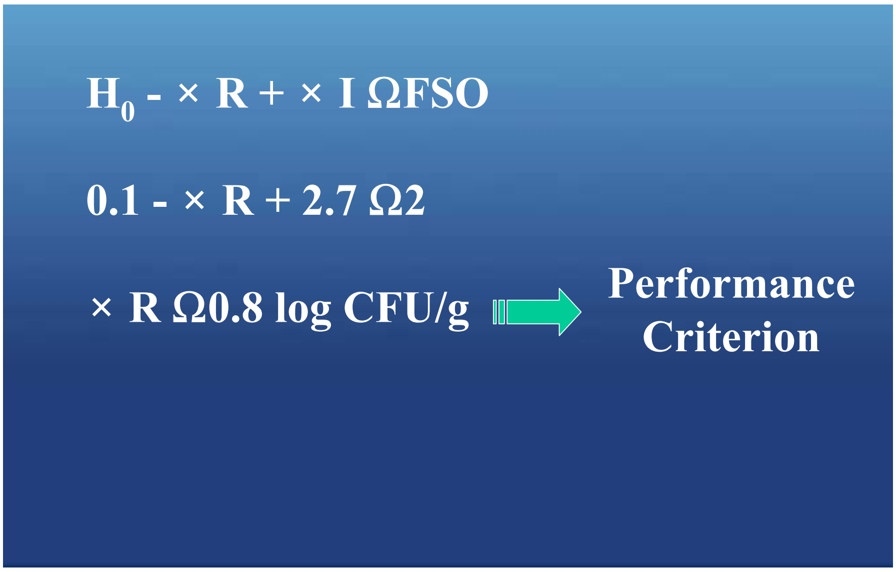

Figure 3. The use of an FSO in a through chain risk management framework.

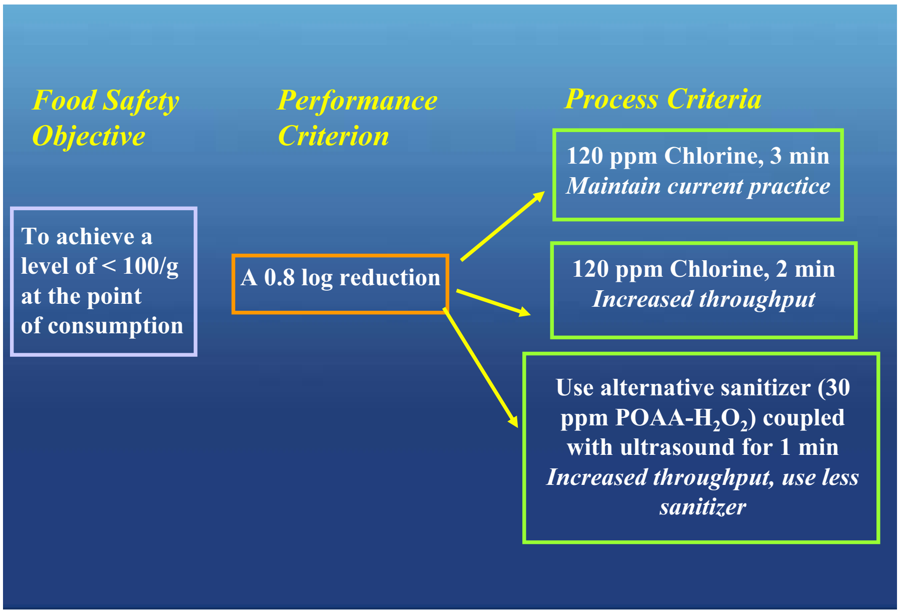

Figure 4.

and socio-economic considerations. Therefore, it should be the responsibility of the appropriate national government authorities to establish the FSO. Nevertheless, the development of internationally acceptable or benchmark FSO could still be extremely useful. When FSOs have been established, establishment of equivalency of one given food safety control measure as compared to another would be greatly facilitated (Figure 3). Also, it would improve the transparency of the given risk management options. In order to make full use of the flexibility in operation this approach will bring, it will be important to be able to validate the equivalency of different intervention measures especially for foods in international trade.

Although the current developments in the concept of food safety objectives have focussed on microbial hazards, in the future, the principles established may also be of benefit in managing chemical hazards and allergens.

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