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Review

Information systems in food safety management☆

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Abstract

Information systems are concerned with data capture, storage, analysis and retrieval. In the context of food safety management they are vital to assist decision making in a short time frame, potentially allowing decisions to be made and practices to be actioned in real time.

Databases with information on microorganisms pertinent to the identification of foodborne pathogens, response of microbial populations to the environment and characteristics of foods and processing conditions are the cornerstone of food safety management systems. Such databases find application in:

- Identifying pathogens in food at the genus or species level using applied systematics in automated ways.
- Identifying pathogens below the species level by molecular subtyping, an approach successfully applied in epidemiological investigations of foodborne disease and the basis for national surveillance programs.
- Predictive modelling software, such as the Pathogen Modeling Program and Growth Predictor (that took over the main functions of Food Micromodel) the raw data of which were combined as the genesis of an international web based searchable database (*ComBase*).
- Expert systems combining databases on microbial characteristics, food composition and processing information with the resulting "pattern match" indicating problems that may arise from changes in product formulation or processing conditions.
- Computer software packages to aid the practical application of HACCP and risk assessment and decision trees to bring logical sequences to establishing and modifying food safety management practices.

In addition there are many other uses of information systems that benefit food safety more globally, including:

- Rapid dissemination of information on foodborne disease outbreaks via websites or list servers carrying commentary from many sources, including the press and interest groups, on the reasons for and consequences of foodborne disease incidents.
- Active surveillance networks allowing rapid dissemination of molecular subtyping information between public health agencies to detect foodborne outbreaks and limit the spread of human disease.
- Traceability of individual animals or crops from (or before) conception or germination to the consumer as an integral part of food supply chain management.
- Provision of high quality, online educational packages to food industry personnel otherwise precluded from access to such courses.

Keywords: Information systems; Databases; Applied systematics; Applications software; Knowledge management; RFID technology

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1. Introduction

In this contribution we will consider the role of information systems in developing effective food safety management protocols and, in particular, the role of databases in achieving this objective. Information systems are concerned with the capture, storage, analysis and retrieval of data providing the opportunity for the cumulative gathering of knowledge and the capability for more informed interpretation of the significance of new data collected to monitor or investigate natural phenomena.

In food safety management a well worn, but still highly illustrative, analogy introduced in 1994 is that of "Cole's Cliff" (Zwietering, 2002) which holds that increasing knowledge of process/product/pathogen combinations and associated variability decreases uncertainty in achieving a positive food safety outcome. Thus, food safety management practices may be positioned closer to the cliff face without decreasing the probability of achieving the desired objective or increasing the probability of a fail-dangerous event.

2. Foodborne pathogens: enumeration and identification

Knowledge of microorganisms and the behaviour of microbial populations in foods for the purpose of developing effective food safety management strategies is required at the population level, the cellular level and the molecular level (McMeekin, 2003).

At the population level we are concerned principally with numbers of microorganisms which, depending on environmental conditions, will increase, decrease or remain static. The elements of the bacterial growth curve have been well characterised at the population level for more than half a century (Monod, 1949) and death kinetics have been described since the early 1900's (Bigelow, 1921; Chick, 1910; Esty and Meyer, 1922; Whiting, 1993). For a wide range of foodborne pathogens population response data has been synthesised into mathematical models that chart changes in pathogen density or describe environmental conditions precluding growth [see Ross and Dalgaard, 2004 for a comprehensive and definitive review of secondary models describing microbial population behaviour].

Whilst a numerical analysis of pathogen levels is the most useful type of information upon which to estimate the risk of foodborne illness, food safety management decisions are often based on "simply" recording the presence or absence of a pathogen in a food or the food processing environment. The decision not to quantify is, in the main, driven by pragmatic considerations of detecting a small number of pathogens with a low prevalence in a lot of food in which, if present, the microorganisms will be distributed heterogeneously or if the accept/reject criterion is based on the absence/presence of a pathogen.

The probability of detection of a particular pathogen is increased by resuscitation or non-selective enrichment of the sample during which damaged or dormant cells repair and start to divide. This is followed by manipulation of the diverse microbiota present in the enriched sample by selective enrichment during which more rapid development of a target organism is favoured. Selective enrichments are usually carried out in liquid media, the microbial components of which are further differentiated and physically separated by plating on solid selective and diagnostic media. Clones, derived from individual colonies, with the characteristics of the presumptive pathogen are subjected to taxonomic tests based on the composition of cellular components, physiological activity or analysis at the molecular level.

Clearly, databases containing information on microbial population behaviour or characteristics allowing the definitive