Food safety risk assessment: part 3 – exposure assessment

Words by Deon Mahoney and Dr Dipon Sarkar

In this third article in the series, we explore the critical issues and approaches for assessing exposure to a hazard in order to objectively inform a risk characterisation that describes the risk to consumers from contaminated food.

Exposure assessment is one of the four components of risk assessment within the risk analysis framework. The Codex Alimentarius Commission defines exposure assessment as *the qualitative and/or quantitative evaluation of the likely intake of biological, chemical, and physical agents via food as well as exposures from other sources if relevant*.[1]

Exposure assessments provide an estimate of the frequency, magnitude, and duration of exposure to specific hazards and other risk factors through the consumption of food, beverages, drinking water and even dietary supplements.

While an exposure assessment may be undertaken as part of a formal risk assessment, in the food industry it usually involves a stand-alone process, where the objective is to quantify the health risk to consumers or determine ways to minimise their exposure. In this situation, information on the identification and characterisation of a hazard has been established, and the exposure assessment seeks to determine the extent to which consumers may be exposed to an identified hazard. This step typically requires the most investigation, involving data collection, scenario calculations and interpretation, and is crucial in identifying situations where consumers may be exposed to potential hazards and in executing targeted control measures designed to safeguard consumer health.

Exposure assessment scenarios

In the food processing environment, there may be a range of situations where an exposure assessment is vital for establishing the risk associated with an identified hazard. Table 1 provides examples of scenarios.

Microbiological versus chemical exposure assessments

Where the hazard is microbiological, there is a need to monitor contamination levels. This may involve incoming raw materials, in-process foods, or finished products. The assessment then seeks to determine whether the level of contamination is likely to increase or decrease during storage, preparation and transport. When assessing finished products, there is a need to consider how the consumer handles the food, confirm typical serving sizes and establish the frequency of consumption. For certain pathogens, there will be a need to ascertain if the consuming public includes vulnerable consumers.

The exposure assessment of microorganisms can be expressed using the ICMSF mass-balance equation,[2] which states that the changes in a hazard from the initial level (H_0), minus the sum of reductions (R) plus the sum of the increase of the hazard through growth, concentration, or re-contamination (I) across the entire food chain is the final exposure concentration of the hazard.

$$H_0 - \sum R + \sum I = Exposure\ Assessment$$

The outputs from the micro-biological exposure assessment indicate the extent of exposure to a pathogen. This information can then be evaluated against microbiological limits in the Australia New Zealand Food Standards Code, guidance in codes of practice, and dose-response curves where they are available (this step is the last step of risk assessment, known as risk characterisation). This will inform decisions on whether to release a product to the marketplace, with a food business's risk appetite a key factor in the decision-making process.

SCENARIO	FACTORS THAT NEED TO BE ASSESSED
Finished product testing confirms the presence of *Listeria monocytogenes* within the legal limit in a ready-to-eat deli food that will not support the growth of the organism	• Potential for the food to be mishandled (including further contamination) in the supply chain • Impact of refrigerated shelf-life on the contamination (time and storage temperature) • Could pathogen level exceed 100 cfu/gram before the end of shelf-life • Potential consumption by vulnerable consumers
Finished product testing shows pesticide contamination in a frozen vegetable product	• Source of the contamination • Contamination levels in finished product • Potential exposure of consumers to the pesticide
Assessing the potential use of river or dam water for the irrigation of leafy green crops	• Background levels of contamination – microbiological, chemical, and particulate • Temporal variations in water quality

Table 1: Exposure assessment scenarios in the food industry.

INFORMATION	SOURCES
Dietary intake	• National Nutrition Survey • Australian Health Survey (AHS): 2011-12 National Nutrition and Physical Activity Survey • New Zealand National Nutrition Survey for adults • EFSA Comprehensive Food Consumption Database
Pathogen growth models	• Pathogen Modelling Program (US Department of Agriculture) • Combase (US Department of Agriculture) • Refrigeration Index Calculator (Meat and Livestock Australia) • Shelf Stability Predictor (University of Wisconsin – Madison)
Databases	• Scientific literature • Public health databases • Challenge studies
Risk assessment tools	FDA-iRISK: Web-based system analysing data on microbial and chemical hazards in food

Table 2: Sources of information.

In the case of chemical contamination, many of the usual hazards are introduced during agricultural production eg., agricultural chemicals, veterinary medicines and environmental contaminants, with little change in levels as the food is further processed. But there are exceptions, contamination levels may increase eg., where fruit is dehydrated, or a juice is concentrated. Alternatively, the level of contamination may decrease through unit operations, such as peeling and washing, or as a result of dilution procedures. Hence, a good understanding of processing operations is essential. Outputs from monitoring chemical contamination are typically evaluated against maximum limits described in the Australia New Zealand Food Standards Code, and a more detailed exposure assessment is often not warranted.

See part two in this series for more details on the type of information required for an exposure assessment.[3]

Sources of data

A dietary exposure assessment requires an estimate of how much of a food a population, or population subgroup, consumes. National nutrition surveys provide detailed data on consumption of foods and beverages and can be accessed to support assessment of the dietary exposure to food additives, pesticide residues, chemical contaminants, nutrients, food ingredients and microbial contaminants.[4] Dietary exposure is then estimated by combining food consumption data (portion size) with hazard concentration data.

Aside from monitoring data obtained during food processing, dietary exposure assessments for microbial hazards require detailed information on food-handling and storage conditions (times and temperatures), as well as food preparation practices in the home. The ability to predict microbial growth and/or survival during food processing, storage, and distribution is important for exposure assessment.

In many cases, access to data on times and temperatures during transport and storage of a specific product is not directly available. Hence, it is often necessary to use databases or surrogate data from other food products. For example, use of temperature profiles along a meat supply chain (Refrigeration Index Calculator),[5] or supermarket cool room monitoring data.

Microbiological modelling programs are useful tools for food manufacturers seeking to model the effects of storage and handling conditions on the growth and/or death of pathogens in a food along the food supply chain. Such programs are a cost-effective alternative to undertaking expensive laboratory experimentation.

Uncertainty and variability

Variability in exposure assessments refers to variability in susceptibilities, contaminant concentrations, and human exposure factors. While uncertainty is related to a lack of knowledge regarding components of the assessment process. Identification of the sources and extent of variability and uncertainty is key to reducing their impact and to the utility of the assessment.

Summary

A thorough exposure assessment strives to portray a real-world situation, depicting possible exposure of consumers to an identified hazard. The assessment can indicate scenarios ranging from most likely to conservative to worst-case, and will support the identification of risk management strategies.

Identification of uncertainty and variability is critical in understanding the limitations of the exposure assessment and in utilising the final exposure estimate.

References

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