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Predictive modelling in foods: An untapped food safety management support tool – Part 1

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Food producers have a huge responsibility to protect consumers through the production of safe and quality food. Predictive Microbiology, an evolving area within the field of Food Microbiology, could proffer a scientific, rapid, accurate and cost-effective method of ensuring safety of processed food products. Predictive models (PM) applied here are developed based on validated laboratory-generated data, and are incorporated into user-friendly software to predict the growth, survival, or inactivation of microorganisms in food under specific environmental conditions.

The scientific foundation of PM is that microbial responses in foods are reproducible against several extrinsic and intrinsic environmental factors. Evidence of the importance of Predictive Microbiology for supporting the decision-making process concerning food safety can be seen by its requirements as a food safety assurance approach in different standards for Food Safety and Quality Management Systems (FSQMS). Predictive models have been incorporated as helpful elements into the self-control systems such as Hazard Analysis for Critical Control Point (HACCP) programmes, shelf-life studies, innovation and development of a new product, and food safety risk-based metrics.

National and international food safety policies are now based on the development of Quantitative Microbial Risk Assessment studies, which are greatly supported by the application of PM. Models have been used extensively in many scientific disciplines, and food producing companies such as Nestlé, Unilever and Heinz apply PM as a necessary tool to support decisions concerning food safety and quality. Meat and Livestock Australia (MLA) testified that PM reduced the risk of illness and death from listeriosis, contributing to saving the equivalent of four lives every year.

Determination of shelf life is one of the most promising applications of predictive microbiology to food industries, rendering a reliable and economic tool for obtaining rapid estimations. This can also be a useful tool for South African food industry professionals to determine the impact of various treatments or conditions on microbial behaviour in food products and reduction of food waste.

What is Predictive Food Microbiology?

Predictive modelling in foods is a broad scientific field within the field of Food Microbiology, which provides mathematical models to quantitatively predict the behaviour (inactivation, survival and growth) of micro-organisms based on information about the organism, product and process characteristics. The first predictive models were developed in the 20th century, where Bigelow and Esty (1920), Bigelow (1921), and Esty and Meyer (1922) proposed a log-linear model to describe bacterial death kinetics by heat. This model is widely used in the food industry to determine the inactivation of *Clostridium botulinum* in low-acid canned foods during thermal processing. As a result of computer advances and statistical software packages, the use of modelling in food microbiology has expanded drastically with the development of numerous user-friendly software that are used to predict microbial responses within the food environment.

These computer software models provide an interface between the underlying mathematical functions and the user, allowing model inputs to be entered and estimates of microbial responses to be observed through simplified graphical outputs.

Application of predictive modelling by the food industry

Despite the huge efforts by the South African food safety authorities, specialists and industry, food safety remains critical and often comes into the spotlight with outbreaks that can bring a stack of multiple negative consequences. Hence, evaluation, control, reduction and/or elimination of these hazards are important in relation to public health. Modelling the behaviour of pathogens in food products is a basic tool for the prediction of food quality and safety, and this can be assessed during the various steps of the food chain. Accurate prediction of bacterial growth/survival/inactivation in food products during processing, transportation, or storage at retail or domestic levels provides valuable data on the safety of the food product while reducing cost. This enables food processors to reduce the amount of traditional experimental work that is required to test and ensure food safety and consequently assign an accurate shelf life.

Some potential applications of PM that can be explored in South Africa include:

- ***HACCP*** – Determine process criteria and control limits, hazard analysis, evaluation of variables' interactions
- ***Shelf-life studies*** – Growth predictions of spoilage and pathogenic microorganisms in foods
- ***Design, implement and validate Food Safety Plans/ Processes –*** Validation of control measures, assessing impact of process deviations on microbiological safety and quality of food products
- ***New product development*** – Evaluation of the impact of microbial spoilage on a food product, effect of processing on food quality and safety, evaluation of the effect of other additional factors throughout the food chain
- ***Develop science-based policies through Quantitative Microbial Risk Assessment (QMRA)*** – Estimation of microbial population dynamics along the food chain, exposure assessment towards a specific pathogen

- ***Hygiene measures and temperature integration*** – Evaluation of the consequences of chill chain application on microbial spoilage, optimisation of thermal and non-thermal inactivation processes

- ***Incident support*** – Estimating the impact on consumer safety or product quality in case of problems with products on the market.

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Conclusion

Besides economic issues for the food industries, the desire to produce safe food is based on understanding sources and magnitudes of hazards. PM serves as a scientific support tool, offering these solutions to food safety and waste issues caused by the conservative shelf-life estimation by food producers, while enabling both large- and small-scale businesses to have access to food quality and safety assurance tools at low cost.

We conducted a research study on the application of tertiary models (ComBase, FSSP, Microhibro and PMP) to accurately predict the response of *Listeria monocytogenes* in RTE meals (beef lasagna and egg noodles) sold in South Africa. A challenge study with *L. monocytogenes* in beef lasagna and egg noodles was conducted and the response from this study was compared with predictions by the different software packages.

The outcome of this research showed that tertiary models were applicable in the South African context, and that the predicted data agreed with the experimental responses observed during the challenge test.

References are available

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