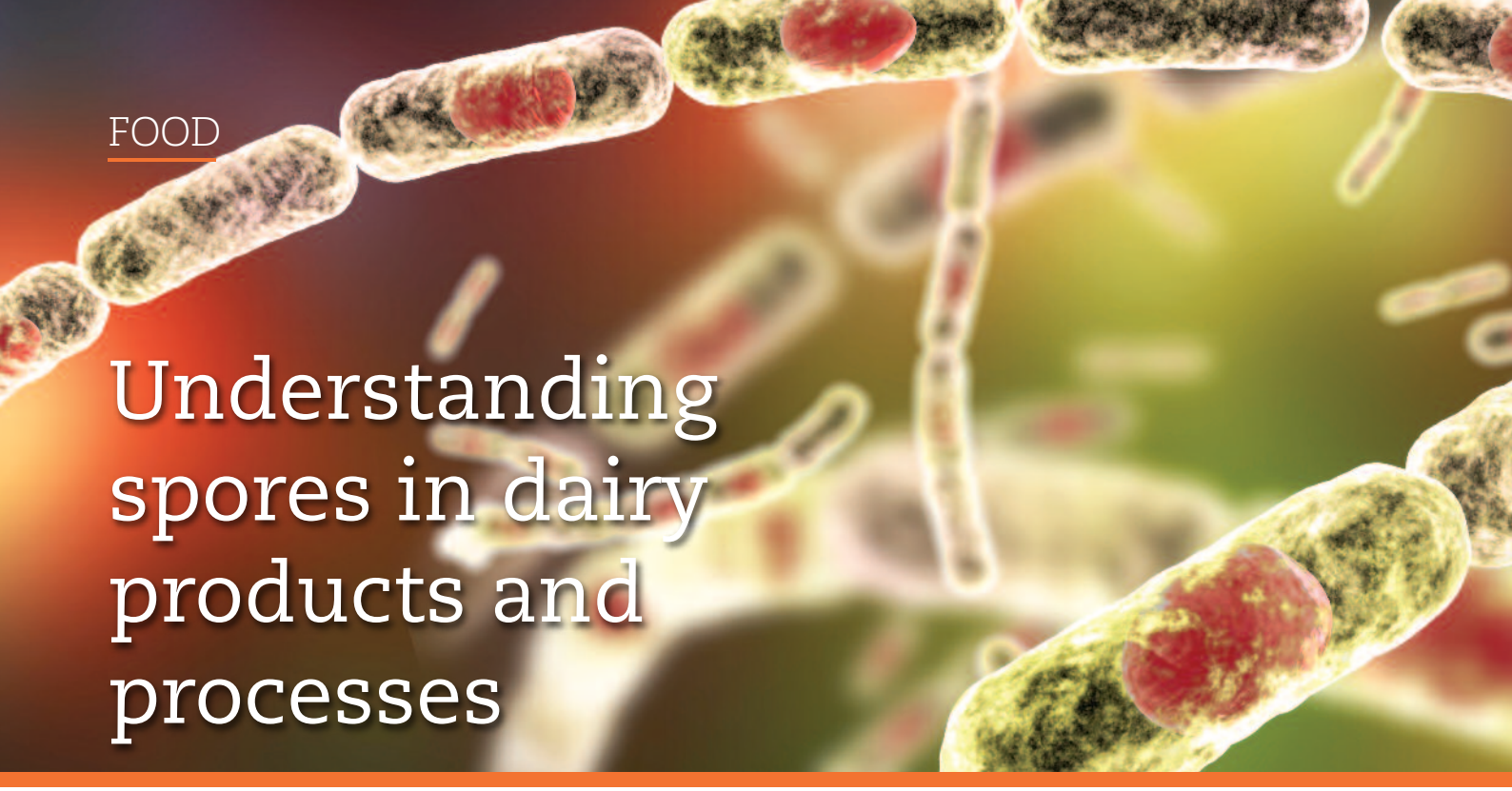

Understanding spores in dairy products and processes

TEAGASC Food Research Centre, Moorepark, in collaboration with Tyndall National Institute, are pushing the boundaries in understanding the fate of spore-forming bacteria in dairy processes including entry, survivability and identification.

The dairy industry in Ireland continues to expand its production capacities post the abolition of milk quotas in 2015, with the vast majority of our dairy produce destined for export markets. While there is unprecedented commitment and vigour in the industry, the challenges surrounding the maintenance of the high food safety standards for which Irish produce is known remains at the fore for those involved in the agri-food sector. Teagasc continues to support the Irish dairy industry in addressing a rapidly evolving food safety environment, and is currently leading a project in collaboration with Tyndall National Institute focused on identifying the key problematic spore-forming bacteria in Irish powdered dairy ingredients. The project looks at Spore Analysis Critical Control Points (SACCP) for their control in the dairy factory, and will provide applied research outputs to support the continued high level of food safety already prevalent in the industry. Through understanding the behaviour of spores in the dairy process, the SACCP project will minimise the risk of any future food safety scares.

Quality by design or control

The question is often raised as to whether we should apply a philosophy in our industry of quality by design or quality by control. The SACCP project aims to address both of these questions by modelling the behaviour of highly heat-resistant spores during thermal processing in concentrated dairy streams, while also evaluating alternatives to high heat treatment such as filtration processes and emerging microwave volumetric heating technologies (**Figure 1**), as lower thermal load processes with higher spore eradication efficiency than conventional heating processes. To address control of microbiological quality in finished products, the project is developing next-generation molecular microbiology approaches that may in the future supersede classical microbiology methods currently used as industry standard for identification and quantification of heat-resistant spores. The SACCP project revolves around three thematic areas focused on microbiology, technology and sensors.

Microbiology

Assessing the performance of existing classical microbiological methodologies for spore detection, it is clear that traditional culturing techniques are slow and provide little information without further investigation. Novel shotgun metagenomic sequencing allows detection and identification of possible pathogens and spoilage bacteria in parallel with strain level analysis and functional gene analysis, such as identification of toxin genes.

This approach has the potential to be of great value with respect to the detection of spore-forming bacteria, and could allow a processor to make an informed decision surrounding process changes to reduce the risk of spore contamination.

The continued development of next-generation sequencing techniques for the isolation and identification of spore-forming bacteria in both products and processes may form the basis for quality control laboratories in the dairy industry in the future.

Technology

The SACCP project is assessing the survival of highly heat-resistant spore-forming microbes (*Geobacillus Stearothermophilus*) in pilot heat exchangers using model dairy systems (skim milk) at elevated dry matter contents, with the aim of understanding the protective effect of increasing dry matter contents on the survival of spores in dairy processes. Additionally, novel, state-of-the-art processes are being evaluated, such as microwave volumetric heating, as a potential new technology for control of spores in the dairy factory.

Because microwaves transfer electromagnetic energy at a molecular level, and the vibration of the molecules creates heat through friction, microwave heating could provide more effective spore inactivation at lower time temperature combinations than conventional methods of thermal processing. Current investigations are exploring the potential of microwave heating to reduce highly heat-resistant spore numbers within model dairy systems.

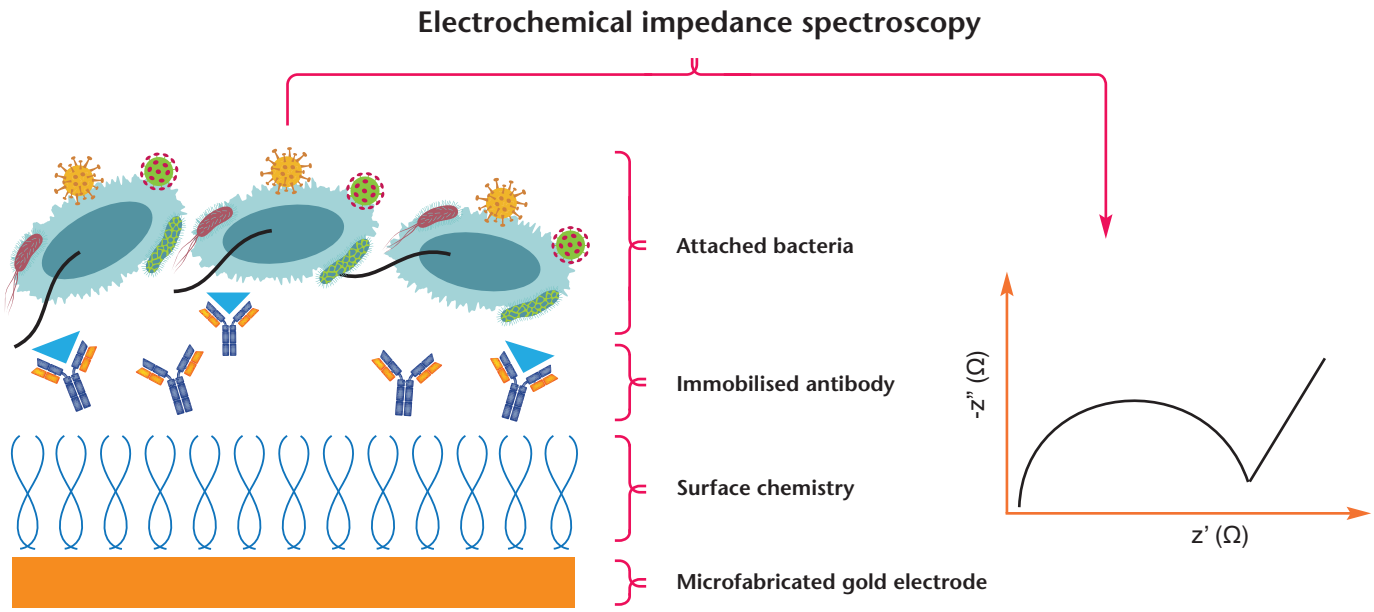

FIGURE 2: Proposed biosensor under development by Tyndall National Institute for detection of spores.

FIGURE 1: Microwave volumetric heating system being assessed in the SACCP (http://www.advancedmicrowavetechnologies.com/equipment/).

Sensors

Tyndall National Institute is responsible for the development of biosensors that are specific to certain spore-forming bacteria. An electrochemical-based approach is being used, which facilitates the design and fabrication of miniaturised and disposable sensing chips. The sensor consists of a three-electrode cell: a working electrode, counter electrode and reference electrode. The Tyndall group is focused on the design and demonstration of electrochemical biosensors capable of being used 'at-line' during dairy processing, which can identify and quantify spore-forming bacteria in real time. The sensor design employs what is known as the lock and key approach whereby a particular 'agent' that responds only to the presence of the target 'agent' or organism is attached to a solid electrode. When an appropriate spore arrives at such a surface it attaches via quite strong chemical bonds that can only form between the spore, which may be called the 'antigen', and the adsorbed bioactive species, which may be called the 'antibody'. So, the detection of the spore in this instance will occur via the selective binding of the target organism to the specially prepared electrode surface using a method known as electrochemical impedance spectroscopy (**Figure 2**). While the complete elimination of spore formers from the dairy supply chain will remain an area of continuous improvement, the successful delivery of the SACCP project will help to future-proof food safety for the dairy industry by seeking state-of-the-art solutions for the detection and eradication of spore-forming bacteria within the processing chain.

Acknowledgements

Triona Hunt (Teagasc), Kieran Jordan (Teagasc), Francis Butler (UCD), Vuslat Buk (Tyndall), Karen Twomey (Tyndall), Martyn Pemble (Tyndall), and Phil Kelly (Teagasc). This research was funded by the Department of Agriculture, Food and the Marine (DAFM) under the FIRM project 'SACCP', reference number 14/F/883.

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