SESSION 4.1:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS ON-FARM

Biofertilisers and enhanced efficiency fertilisers – solutions for the future

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Abstract

The rising costs of fertilisers, disruptions in supply chains due to COVID-19 and global conflicts, and a focus on soil health have led to increased interest among growers in using alternative inputs for improved cropping systems. Recycled organics derived from intensive livestock operations and food waste contain valuable nutrients and organic matter, which can enhance soil characteristics, increase crop productivity, reduce reliance on inorganic fertilisers, and promote resilient farming systems. The Incitec Pivot Fertilisers' (IPF) Australia biofertilisers (ABF) is made with a sterilised and dried organic waste materials from poultry sheds, combined with inorganic chemicals, resulting in organo-mineral granules that provide necessary nutrients, organic matter, and labile carbons in a single granule. ABF technology is one example of efficient waste recycling where most of the nutrients and carbon are retained from the waste as opposed to being lost to the atmosphere as greenhouse gases, in alignment with the principles of circular economy. The main barriers to adoption are the high capital cost of building in Australia and the cost of renewable energy to run the process. Similar challenges are faced by other emerging technologies such as green ammonia. Perhaps the greatest opportunity for farmers is to adopt inhibitors which can minimise gaseous and leaching losses from existing nitrogen fertilisers. Nitrogen fertilisers are essential to crop production, but more than half of the fertiliser applied to crops is lost due to leaching or volatilisation. The IPF inhibitors can reduce greenhouse gas emissions by up to 80% from fertilisers and in some cases allow rate reduction without impacting yield and quality of produce. IPF conducted a study comparing their patented technologies of biofertilisers and nitrification inhibitors with standard farming practices for celery cultivation in East Victoria, demonstrating similar crop yields, reduced emissions and providing application efficiency.

My talk is about the future fertilisers, focusing on nitrogen inhibitor technologies and biofertilisers developed in line with the principles of circular economy. It is my first time attending a Crawford Fund conference and I must say I am very impressed with the organisation itself and the people behind it. I really hope that one day the Crawford Fund can help set up research & development in the region of my original home, Afghanistan, helping them restore their agricultural economy.

I am here representing Incitec Pivot Fertilisers (IPF), to tell you about some future fertilisers, and current fertilisers, that are having an impact on the future for the industry. In case you are not already aware of our business, for over 100 years we have been an Australian manufacturer and distributor of fertilisers, with outlets throughout Australia and exporting to a range of other regions. We annually manufacture about 1 million tonnes of fertilisers, as ammonium phosphate, and sulfate of ammonia, and we distribute about 2 million tonnes. That amount includes our own manufacturing and exports, as well as fertilisers we import into Australia for local consumption. In other words, although we operate predominantly in Australia, we are part of the global agriculture system (Figure 1).

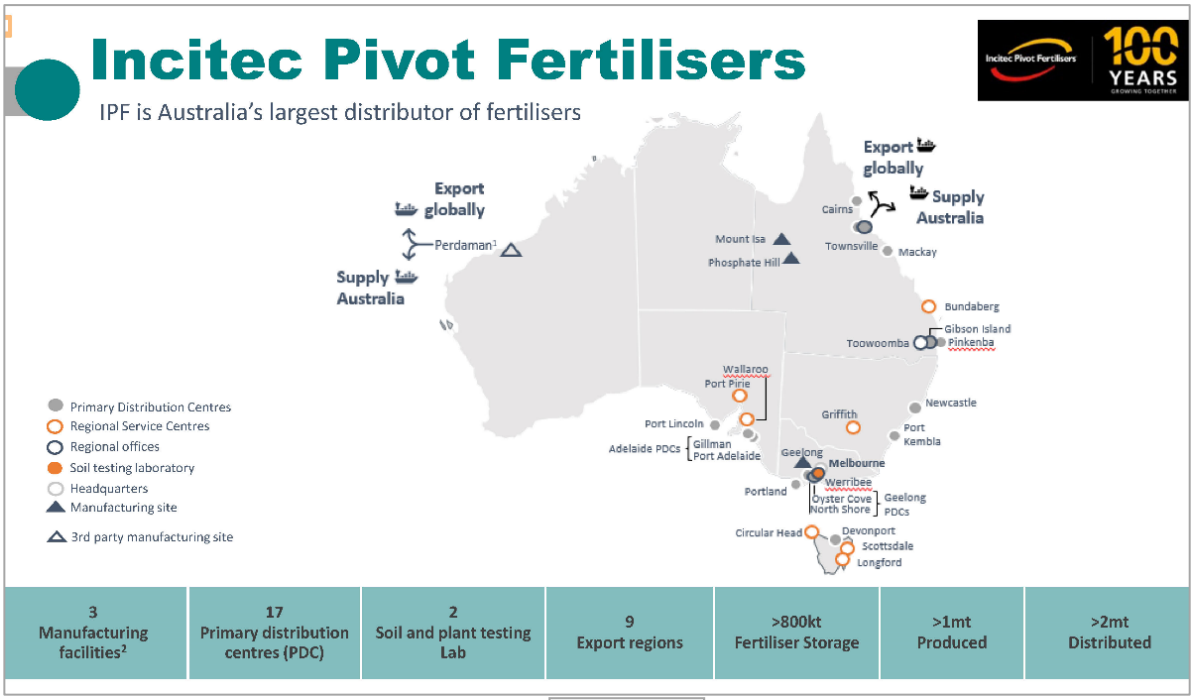

Figure 1.

Our fertiliser technologies

Figure 2 is an overview of two of our fertiliser technologies. Nitrification and urease inhibitors are not new: they have been in the industry for at least 20 years, and Incitec Pivot has had the products in Figure 2 available for about ten years. However, they have a new-found purpose because they benefit the environment by reducing gaseous losses. ***eNpower***® is an Incitec Pivot technology developed and IP-patented under the *eNpower*® trade name. It's a nitrification inhibitor that slows down the conversion of ammonium to nitrate when the fertiliser is applied

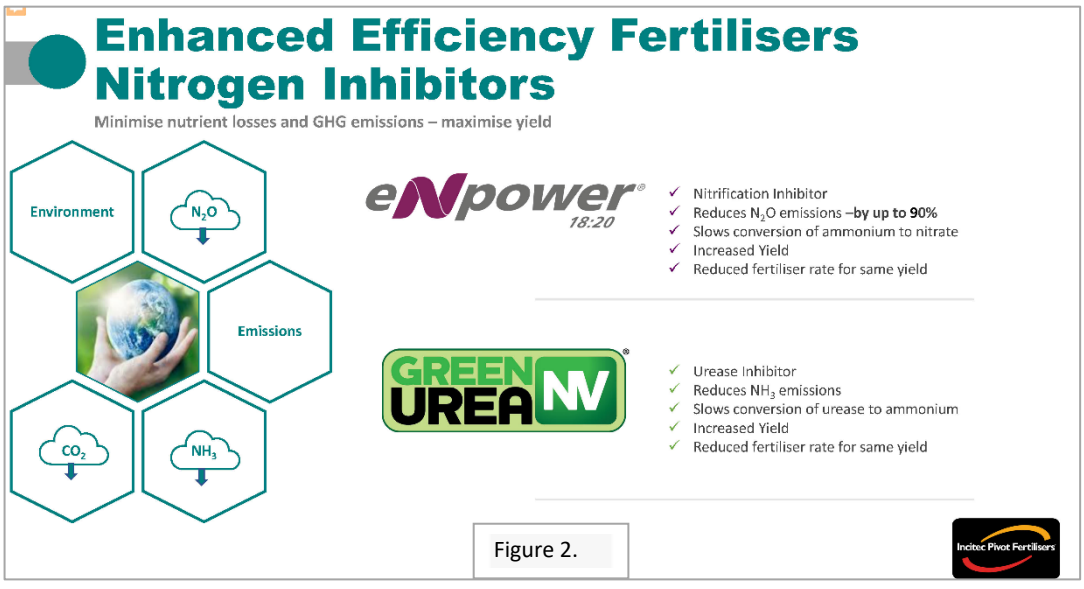

Figure 2.

into the soil, making the nutrient available to the plants for a longer time; and as a result it also reduces nitrous oxide emissions by up to 90%. The technology is available as a coating to be added to granular nitrogen fertilisers – such as urea, sulfate of ammonia, and ammonium nitrate – but it can also be added to liquid nitrogen fertilisers. **Green Urea NV®** is a urease inhibitor specially made for urea fertiliser. It slows down the conversion of urea to ammonium, making nitrogen available to the plants for a longer time, and as a result it reduces the emission of ammonia gas into the atmosphere. Again, it is available as a coating for granular urea, but it can also be added into urea as a liquid fertiliser.

They are important technologies because on average only 50% of nitrogen fertiliser applied into the soil is used by the crop; the remainder can be lost in leachate or as ammonia gas or nitrous oxide escaping into the atmosphere. Ammonia gas is an air pollutant. However nitrous oxide is more serious because it is considered a greenhouse gas, having a global warming potential almost 300 times that of carbon dioxide, and also being responsible for ozone layer depletion. Nitrous oxide has been under discussion lately in the industry and by governments. Figure 3 illustrates Green Urea NV® reducing ammonia gas volatilisation, and *eNpower*® reducing nitrous oxide emission. We have a database of the details of trials with these products in different cropping systems, different soils, and different regions in Australia.

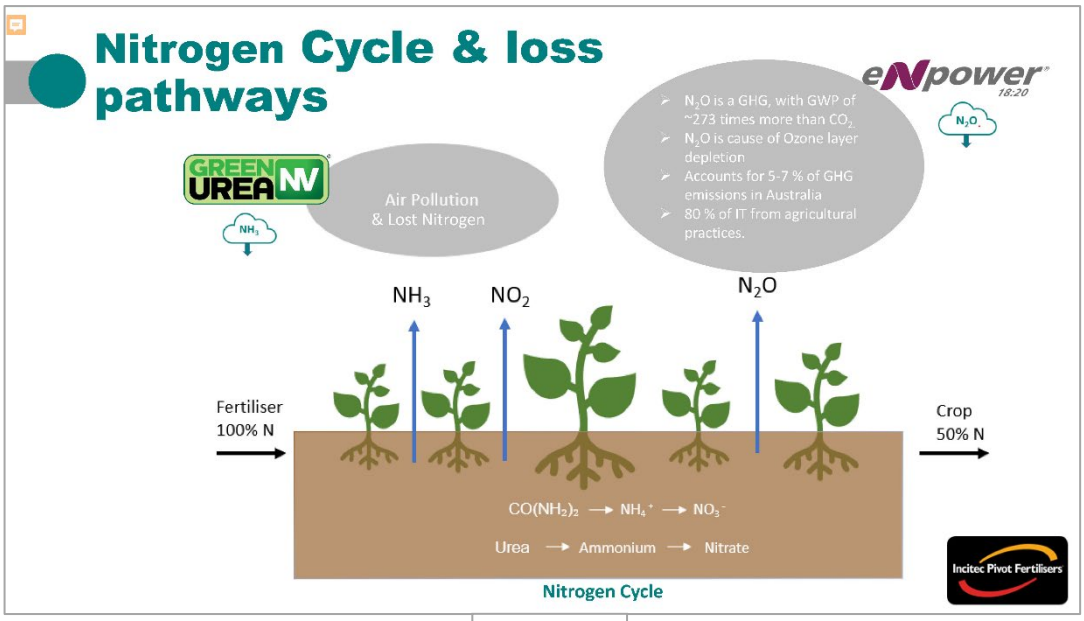

Figure 3.

An independent study published by CSIRO (Schwenke & McPherson 2018) used anhydrous ammonia (an IPF product) as a pre-plant fertiliser with and without *eNpower*® as an inhibitor, to grow cotton in Gunnedah (in New South Wales) and in Emerald (in Queensland) in two Vertosols (Figure 4). The key messages from Figure 4 are that: (i) yields were the same with or without the addition of *eNpower*® – that is, treatments T1 and T2 in the table in Figure 4. (The third treatment in the table used a different inhibitor – Nitrapyrin – not one of IPF's products.) And (ii) there was significant reduction in nitrous oxide emissions from the soils: 86% reduction at the Emerald site, and 77% at Gunnedah. This old technology definitely presents great potential for the future.

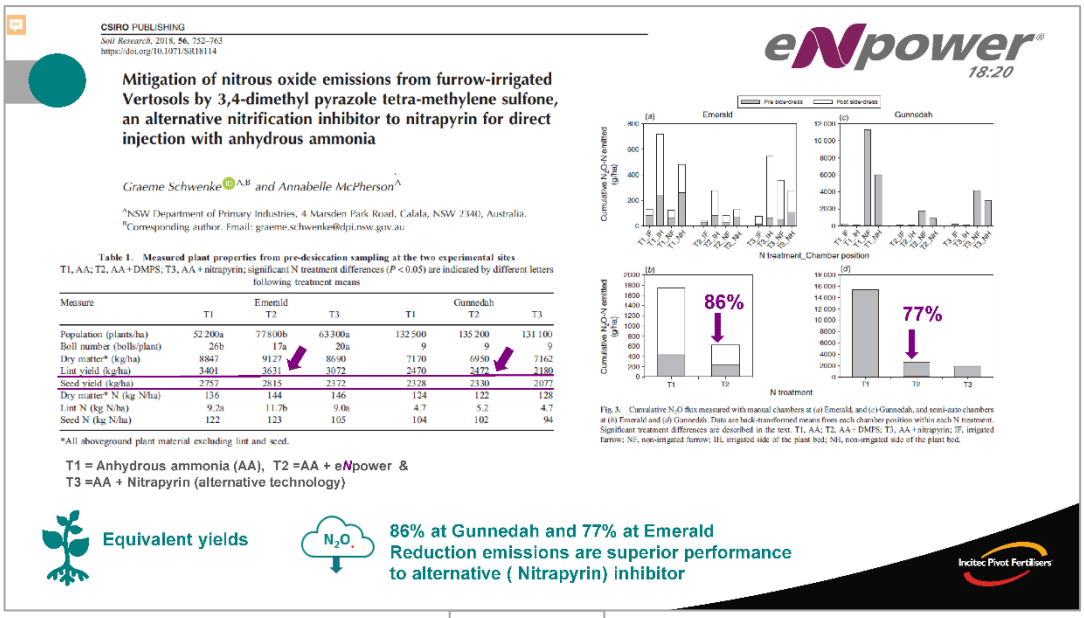

Figure 4.

Bio fert is another new technology, patented globally, which we have developed in recent years. It's a granular organo-mineral fertiliser made from poultry manure that has been sterilised, dried and mixed with inorganic mineral nutrients and some extra functional types of carbon (Figure 5). It looks exactly like an inorganic fertiliser, but has the added benefit of active (labile) carbon as well as stable carbon to stimulate microbial activity in the soil and promote carbon sequestration respectively. There is a range of formulations (Figure 5), created to match the kinds of chemical

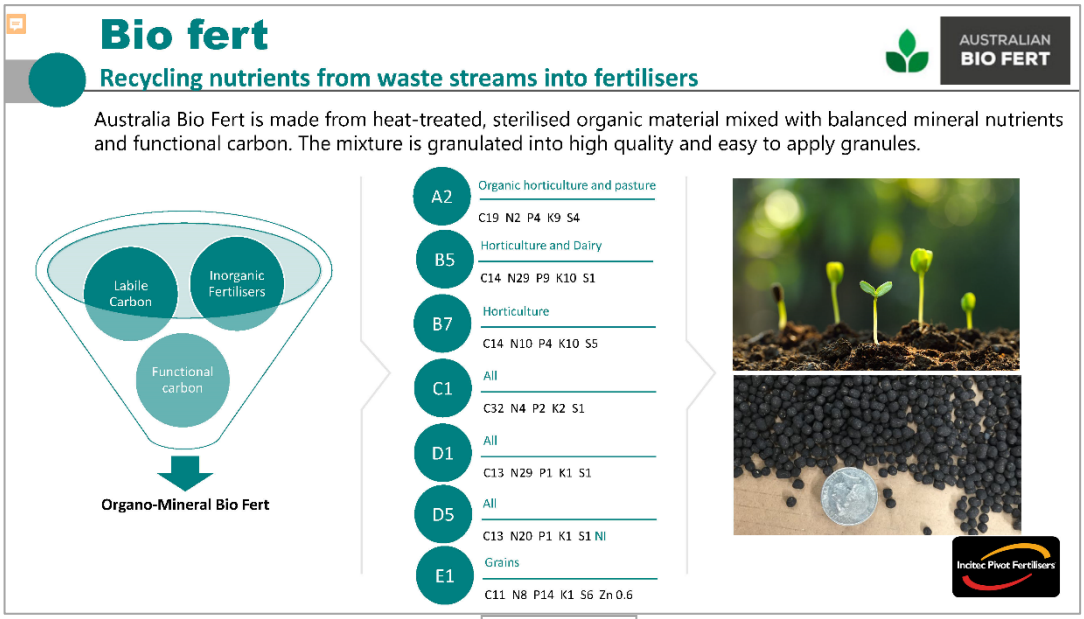

Figure 5.

fertilisers already available for different segments of the market. The technology is very versatile, so we can formulate any nutrient analysis, any carbon : nitrogen ratio that we want. Also we can use other waste streams, such as manures from cattle sheds, or food waste, or other forms of waste. Results from many field trials in various cropping systems have shown that applying Bio fert alone results in yields that are equal to or better than those obtained using inorganic NPK fertilisers with or without added manures.

An independent study by La Trobe University in 2022 combined our inhibitor technology with our Bio fert technology to test nitrous oxide and carbon dioxide emissions from celery crops, grown with standard manure + inorganic fertiliser with or without added *eNpower®* and/or Bio fert (Figure 6). You can see that the yields are very similar with all the treatments. However, adding eNpower®, and/or Bio fert with its functional carbon and stable carbon, reduced nitrous oxide emissions and CO_2 emissions. It appears these new technologies can work together to help reduce emissions into the future.

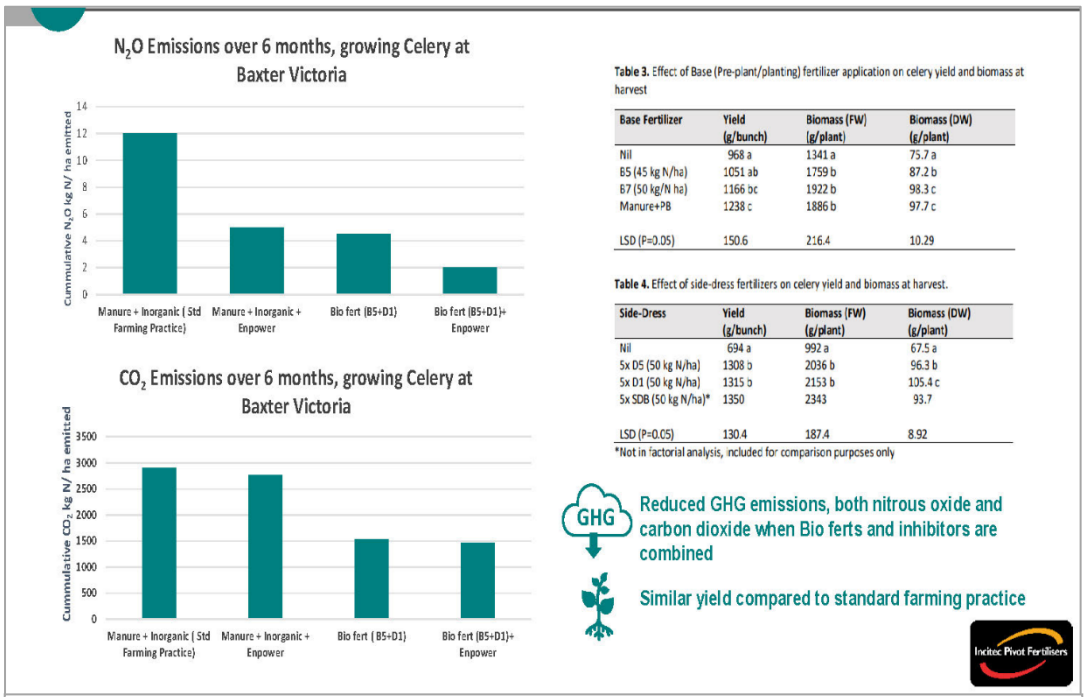

Figure 6. Study by La Trobe University combining inhibitors with Bio fert technology.
Source: Australian Bio Fert.

Looking ahead

Figure 7 is a futuristic framework or pipeline of innovation for Incitec Pivot, in alignment with Scope 1, 2 and 3 carbon emissions and Net Zero Australia 2050. Predominantly it includes development of new technologies, but also our conversion to renewable energies wherever that is possible and feasible for us, such as in our manufacturing facilities and in the footprint of our vehicles and equipment.

We will continue to develop new and improved inhibitor technologies, both in-house – we are just launching a new dual action inhibitor fertiliser into the market this year – and also through

collaborative research partnerships. For instance, The University of Melbourne has a smart fertilisers hub developing new inhibitors that are more suited to Australian soils, and further developing bioferts using recycled nutrients and validating different wastes for that bio-technology. We need a range of waste streams to make sure we will have enough raw materials to continue with that technology at commercial scale.

More important, in the long term, is green hydrogen technology. Incitec Pivot is the only group in Australia in a joint development program with Fortescue Future Industries – which is Andrew Forrest's initiative to validate the production of hydrogen through the electrolysis of water. The first stage of this technology will be green hydrogen for fuel and energy, but we hope we can take the technology further to produce green ammonia for fertiliser, not only in Queensland where we manufacture urea, but also later expanding into our other Australian facilities.

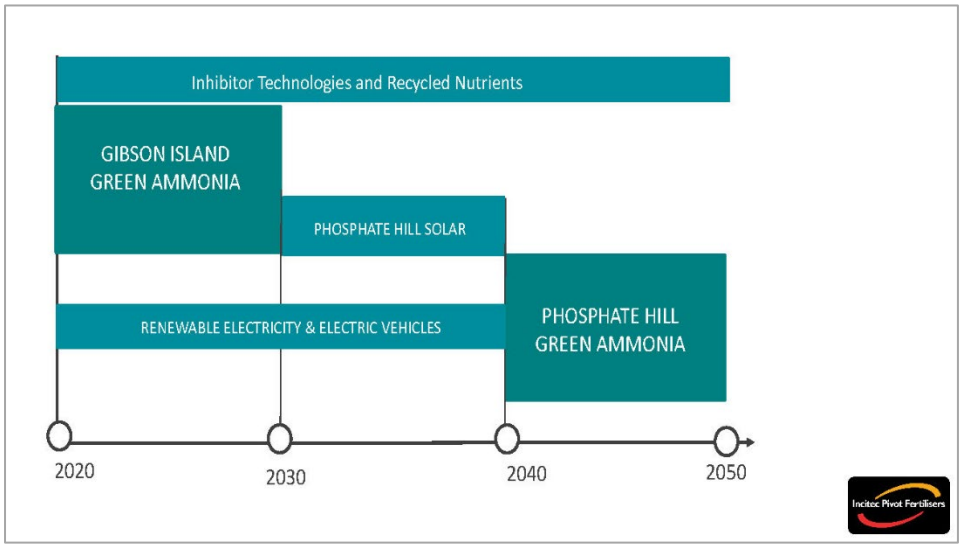

Figure 7.

References

Schwenke G., McPherson A. 2018. Mitigation of nitrous oxide emissions from furrow-irrigated Vertosols by 3,4-dimethyl pyrazole tetra-methylene sulfone, an alternative nitrification inhibitor to nitrapyrin for direct injection with anhydrous ammonia. *Soil Research* **56**: 752–763. https://doi.org/10.1071/SR18114

Dr Roya Khalil is an accomplished business leader with over 19 years of experience in R&D and innovation management across diverse industries, including FMCG, Dairy, Chemicals, and Agriculture. Qualified with a bachelor's degree, a PhD in Chemical Engineering, and an MBA specialising in strategic innovation, she has held key positions with industry leaders such as Incitec Pivot Limited, Orora Packaging, Bega Cheese, Coca Cola Amatil, SPC Ardmona, and Plantic Technologies delivering several commercialised patented technologies. Currently, as the Director of Research and Development at Incitec Pivot Fertilisers, Roya leads the R&D function, focusing on developing enhanced efficiency fertilisers, recycled nutrient-bio based fertilisers, soil health technologies, greenhouse gas emissions benchmarking, and mitigation strategies for the benefit of Australian growers. She actively contributes to cutting-edge research and commercialisation as a Partner Investigator at the ARC research hub for smart fertilisers at The University of Melbourne. Additionally, as an Industry Adviser at the ARC Research Hub for nutrients in the circular economy, Roya is committed to promoting sustainable practices and driving innovations fostering the reuse of nutrients from waste

aligned with principles of circular economy. Roya's expertise extends to co-supervision of PhD students and guest lecturing for Master and Bachelor of Food Engineering at Monash University, RMIT University, and UNSW. She has also been involved as a researcher in numerous programs, including CRC-polymers for biopolymers, Dairy Innovation Australia, and the Australia–China Joint Resource Centre with Monash University. With a comprehensive understanding of the entire food supply chain gained through her diverse career, Roya is dedicated to developing integrated solutions and contributing to a more sustainable and innovative future for the industry.