University of
Southern Queensland

Manufacturing Research

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Research at the University of Southern Queensland

The University of Southern Queensland is a dynamic, regional University that has established its position as a prominent teaching and research institution, providing education worldwide from three physical locations across South East Queensland (Toowoomba, Springfield, and Ipswich) with an extensive online presence. The University's mission is to drive economic and social development through higher education and research excellence.

University researchers are working directly with local communities, industry, and our international partners to form strong and enduring research partnerships that deliver tangible benefits and real impact. The University's world-class research institutes, centres and faculties are home to unique state-of-the-art facilities enabling our researchers to deliver a broad range of research outcomes across multiple disciplines.

The University's Flagship Research Areas

- Agriculture, including Climate Science, Drought Mitigation and Adaptation, Crop Health, Agricultural Technology and Environmental Science.
- Space and Defence, including Astrophysics, Hypersonics and Rocketry, and Materials Engineering.
- Regional Development, including Agribusiness, Economic Development and Cultural Heritage.
- Health, including Sport and Exercise Science, Mental Health and Allied Health.

Research Excellence

The global reach and world-class quality of the University's research is confirmed by International Rankings and the Australian Research Council's Excellence in Research for Australia (ERA) Report. In the 2018 ERA Report, the University's research was rated as 'world standard or better' in 30 areas of research and 18 fields of research were rated as 'well above world standard'.

The following 18 fields of research received the ultimate accolade of 'well above world standard'

Astronomical and Space Sciences
Materials Engineering
Mechanical Engineering
Numerical and Computational Mathematics

Environmental Science and Management
Agriculture, Land and Farm Management
Crop and Pasture Production

Physical Sciences
Medical and Health Sciences
Human Movement and Sports Science

Clinical Sciences
Psychology
Nutrition and Dietetics
Public Health and Health Services

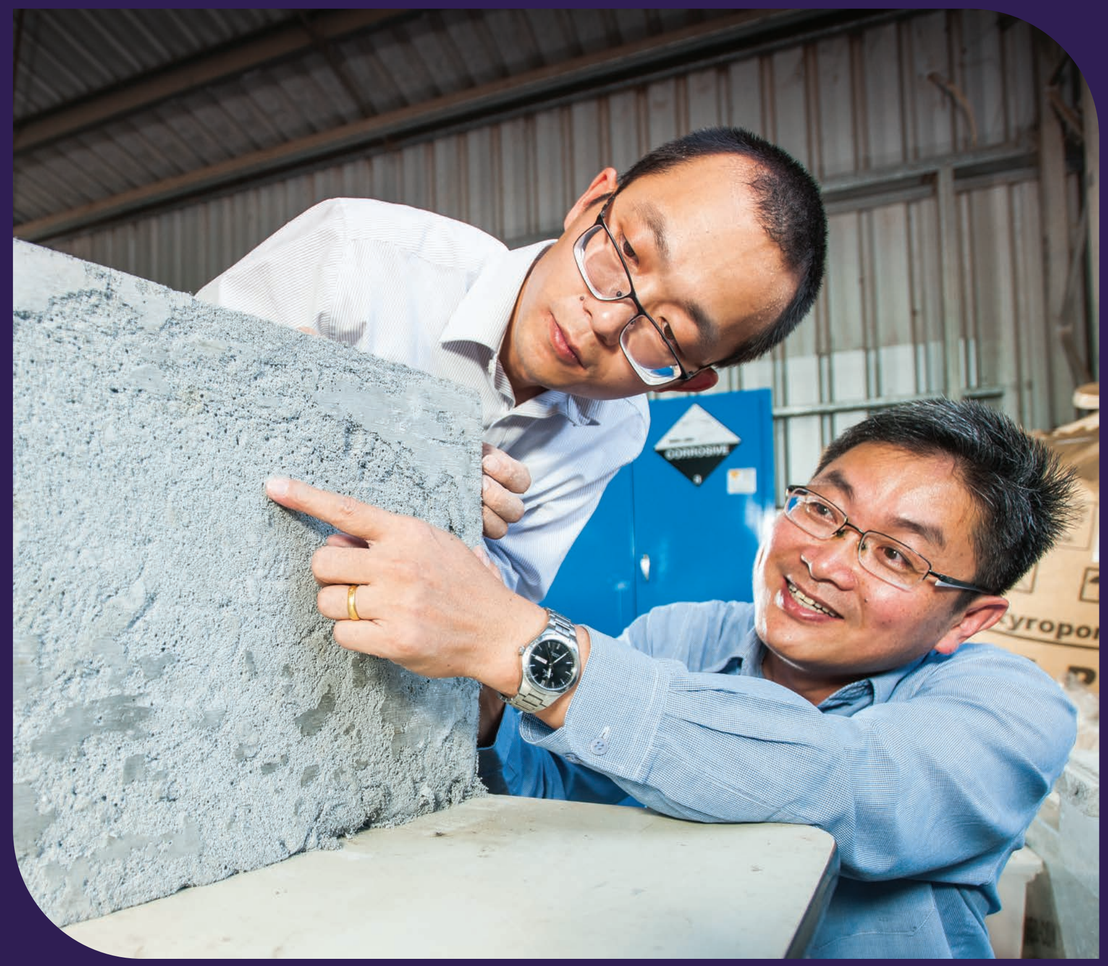
Chemical Sciences
Inorganic Chemistry
Macromolecular and Materials Chemistry
Microbiology

In the Times Higher Education World Rankings, the University of Southern Queensland is ranked in the 301 - 350 band and is in the 151 - 175 band for Engineering.

In the Times Higher Education Young University Rankings, the University of Southern Queensland is ranked 86 in the world.

The University of Southern Queensland's Manufacturing Research Portfolio

The Centre for Future Materials has expertise in the development of high-strength advanced structures suitable for high-value markets such as the oil, gas and transport industries.



Manufacturing Research

The Institute for Advanced Engineering and Space Sciences provides a dedicated facility for the University's manufacturing research activity. The Institute is home to one of Australia's largest dedicated composite materials manufacturing and testing facilities.

The Institute's Centre for Future Materials conducts pioneering research and development in engineered fibre composites, advanced composite manufacturing, civil composites, smart materials, and geopolymer and concrete.

The Institute is also home to the Centre for Agricultural Engineering; an internationally recognised leader in research focused on improving the profitability, environmental sustainability and socio-economic wellbeing of our rural industries and their natural resource base, as well as the manufacturing and service sectors which support them.

Research Capabilities

- **Advanced Composites Manufacturing** including industry-scale automated manufacturing cells such as filament winding, braiding and pultrusion; testing of fibre reinforcement permeability; aerospace composites repair; and resin infusion processing for the aerospace, space and defence sectors.
- **Circular Economies** through the exploration of waste recovery and energy efficiency options that will enable industry to generate self-sustaining energy systems.
- **Agricultural Engineering** including automated technologies, vision systems and robotics in food production.
- **Functional Materials** including investigating thermoelectric nanostructures as a 'green' and sustainable energy alternative; shape memory composites for smart engineering structural applications; and composites sensing and prediction.
- **Civil Composites** with a focus on internal reinforcement to concrete structures; composite railway sleepers and transoms; composite jackets for bridge pillar structural repairs; and improving structural performance of reinforced composite slabs with pultruded hollow composite bars.
- **Geopolymers and Concrete** including the development of fire-resistant, high-temperature geopolymer from waste streams such as fly ash; and the development of commercially viable, stable and highly durable geopolymer products.

The Centre for Agricultural Engineering has developed machine vision systems in partnership with agricultural machinery manufacturers such as John Deere.

Infrastructure

- **Filament winding facility:** Australia's most advanced 8-axis filament winder to support pressure tank research and ultra-high temperature oxide processing.
- **Dual layer robotic braiding facility** capable of manufacturing high performance complex tubular composite structures for defence and space applications.
- **Resin infusion composite manufacturing:** Aerospace grade composite manufacturing and characterisation equipment.
- **Process and in-service sensing systems** including the only system in the world for 16,000 node pressure sensor mats for monitoring pressure evolution in vacuum and autoclave processing (0 to 12 bar). A Dielectric Analysis to monitor internal laminate cure progression and a full field digital image correlation strain mapping system.
- **Fire and thermal performance** including a full fire testing and analysis suite with a blast furnace which reaches 3500° to simulate harsh rocket exhaust environments.
- **Mechatronic Laboratory** access for developing instrumentation and monitoring systems.
- **A one hectare fully enclosed** site to carry out field trials.
- **A soil and water testing facility** with highly specialised equipment.
- **Environmental, chemistry and bioresources laboratories** equipped with state-of-the-art automated bioenergy feedstock testing equipment.

Researchers from the Centre for Future Materials work directly with industry to develop cutting edge technologies through applied research.

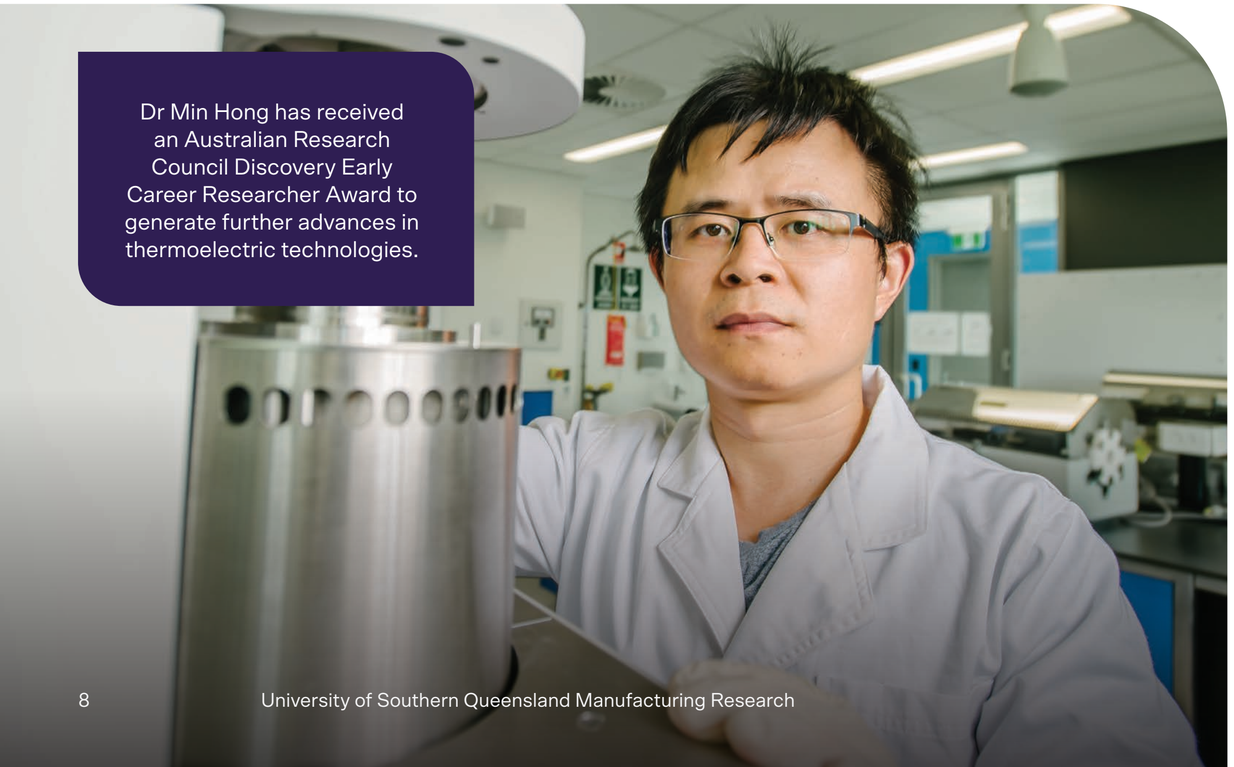
Advanced Composites Manufacturing

The Centre for Future Materials' Advanced Composites Manufacturing Research Team provide novel design, manufacture and testing for the civil construction sector including the aerospace, space and defence industries. Expertise in liquid moulding technologies, automated fibre placement, pultrusion and filament winding capabilities with advanced process modelling tools provide a unique opportunity to develop structures that are lightweight, repeatable and financially sustainable. The University provides partners such as Defence Sciences and Technology (Australia), the US Airforce, US Navy, Boeing and BAE Systems with one of Australia's largest dedicated composite materials, manufacturing and testing capability services, specialising in materials characterisation, polymer analysis, mechanical testing and large-scale structural testing.

Research Projects

Developing high-performance GeTe-based thermoelectric materials

The University has received funding through the Australian Research Council's Discovery Early Career Researcher Award Scheme to investigate high performance thermoelectric materials as a means to generate electricity from waste heat. This research project is exploring a new generation of thermoelectric devices to support the use of eco-friendly energy technology for application in industry.



Dr Min Hong has received an Australian Research Council Discovery Early Career Researcher Award to generate further advances in thermoelectric technologies.

Polymer Composite Transoms for Rail Bridge Deck Replacement

Traditional timber bridge decks used by the rail industry pose several inherent challenges. They deteriorate rapidly and have a limited lifespan of 15 years, have a high fire risk, and are costly to maintain. Repairs and maintenance to timber transoms are extremely disruptive to railway operations.

For the past 20 years, the University has dedicated significant research to developing innovative sleeper and transom technologies.

The University received funding from the Australian Government's Cooperative Research Centre Projects (CRC-P) initiative to partner with Austrak Pty Ltd and Laing O'Rourke Australia Construction Pty Ltd to design, develop and manufacture revolutionary fibre polymer composite transoms.

The project has delivered a cost-effective, robust, and sustainable solution that is currently being trialled at locations throughout the Australian railway network. The progressive technology is expected to deliver significant savings for Australia, which has the sixth largest rail network in the world and is due to replace nearly 90 per cent of its existing transoms in the next 10 years.

Future Proofing Queensland's Infrastructure through Climate Resilient Concrete Technologies

Professor Allan Manalo from the Centre for Future Materials and the School of Civil Engineering has been awarded a Queensland Government Advance Queensland Industry Research Fellowship to develop new, structurally efficient and climate resilient concrete technologies.

Professor Manalo's project has successfully investigated the use of glass fibre reinforced polymer (GFRP) bars which are able to withstand the unstable conditions in marine environments.

University researchers have translated their research expertise directly to end-users by designing a concrete slab reinforced with composite bars which has been installed in waterfront infrastructure at Mooloolaba, on the Sunshine Coast.

As a key outcome of this project, University researchers drafted a technical specification on composite rebars for the Queensland Department of Main Roads, to ensure quality use and application of GFRP reinforcing bars used in marine infrastructure.

The University is partnering with the Queensland Department of Main Roads, Marine Safety Queensland and Inconmat to conduct this project.

Civil Composites: Waste Utilisation

The University's Centre for Future Materials also conducts pioneering research and development in engineered fibre composites, advanced composite manufacturing, civil composites, smart materials and geopolymer and concrete. This includes research that focuses on reducing the amount of waste going into landfill by utilising waste products in new materials for construction and other manufacturing sectors.

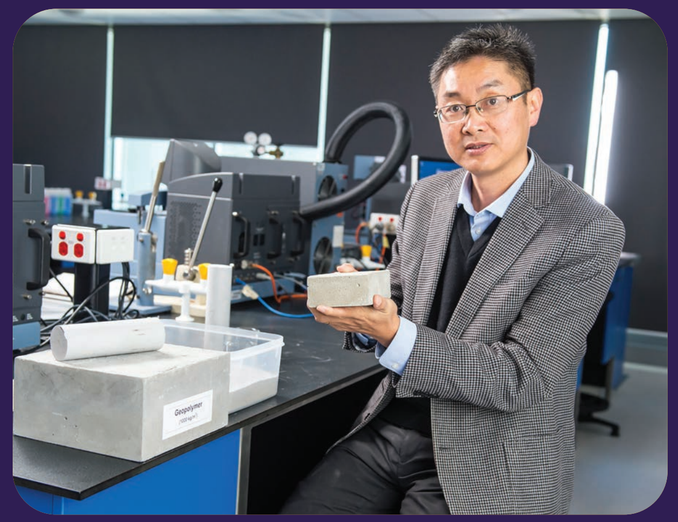
Research Projects

Transformation of Reclaimed Waste Resources to Engineered Materials and Solutions for a Circular Economy (TREMS)

University researchers are collaborating on an $18 million Australian Research Council Industrial Transformation Research Hub focused on reducing landfill waste and transforming unclaimed waste into new materials for use in construction and other manufacturing sectors.

Led by RMIT University, the TREMS research hub involves leading scientists, researchers and industrial experts from nine Australian universities and 36 government, industry and international partners.
The University of Southern Queensland provides industry connections to the hub, including Paintback, Halok, Moreton Bay Regional Council and Tweed Shire Council to investigate converting waste fly ash and paint waste into geopolymer concrete and to seek solutions for waste plastics.

Professor Hao Wang from the University's Centre for Future Materials is the TREMS Theme Leader for Research Theme 2: Optimised processing of recovered resources including waste to energy.



'Green' Concrete

Concrete is one of the most used construction materials by mass world-wide. The production of traditional Portland cement, the most important ingredient of concrete that binds sand and gravels, has a heavy environmental footprint, contributing to 8 per cent of global greenhouse gas emissions. The University partnered with Neilsens, the largest independent supplier of premixed concrete and quarry products in south east Queensland, to come up with viable alternatives. University researchers are focusing on the development of 'green' geopolymer and permeable concrete by utilising high volume coal waste streams such as fly ash, as a sustainable replacement for traditional concrete. Geopolymer has the same long-term performance as Portland cement, but with far less environmental impact.
Australia's heavy reliance on coal-fired power stations results in the production of 14 million tonnes of fly ash per year. Converting this waste to greener options has the potential to dramatically reduce CO^2 emissions. The reactivity of these waste materials makes it difficult to formulate the geopolymer and produce a reliable product.

University researchers have proposed a Reactivity Index to evaluate the suitability of raw materials and the properties of fly ash to determine the best formulation of geopolymer to obtain the desired strength.

Circular Economies: Converting waste to energy and value-added products

Research conducted by the University's Energy and Bioresource Recycling Research Team at the Centre for Agricultural Engineering investigates the viability of renewable energy sources and explores ways of reducing consumption of non-renewable energy on farms and in agricultural industries.

A key area of research focus is the conversion of agro-industrial waste into profitable clean energy with a focus on biogas and biofertilisers from organic waste. Current collaborative projects with the intensive livestock and related food processing industries are focusing on developing tools and practices to better manage waste streams and biogas process optimisation.

Research Capabilities

- Identification of opportunities for recovery of high value-added products to translate the uptake of novel waste management practices across Australian industries.
- Energy and resource recovery of agro-industrial waste.
- Integration of anaerobic digestion processes into farming systems.
- Wastewater analysis and activity testing and degradability analysis.
- Agronomic performance of biofertilisers.
- Best management practices and advice on emerging bioenergy technologies.
- Greenhouse gas mitigation.

Professor Bernadette McCabe explores alternative energy efficiency options that will enable industry to cater for their own energy needs.

Research Projects

ARC Industrial Transformation Research Hub: Nutrients in a Circular Economy (NiCE)

The NiCE Hub is the largest Australia-wide research project on sustainably managing 'nutrients in a circular economy'. By taking a systems-wide view of the nutrient cycle, this project will engage with the most advanced technologies in nutrient management to produce a safe fertiliser for farmers and horticulturalists while identifying the key issues both enabling and challenging the large-scale recovery, and productive re-use of organic wastes to land.

The University is a key partner in the NiCE Hub and is working with water utilities, government departments, energy and resource companies, agricultural and horticultural businesses and local councils to investigate the value of biofertiliser from a range of organic waste streams. The Hub is led by the University of Technology Sydney and has received funding from the Australian Research Council Industrial Transformation Research Hubs and multiple industry partners.

A pilot scale granulator to produce granulated organomineral fertilisers

Agricultural recycling is considered the best environmental option to mitigate the disposal of biodegradable wastes into landfill. However, the chemical composition and physical properties of the resulting recycled product are not always suitable for standard farm spreading equipment.

University researchers are using state-of-the-art granulation equipment that will enable organic material to be blended with synthetic fertilisers and turned into solid granular fertiliser product that can be tested in the field.

The University has received funding for this initiative through the Queensland Government's Waste to Biofutures Fund which supports innovative methods of converting waste into bio-based products and the Fight Food Waste Cooperative Research Centre.

University research is providing circular solutions for agriculture with a focus on the conversion of organic waste and biofertiliser.

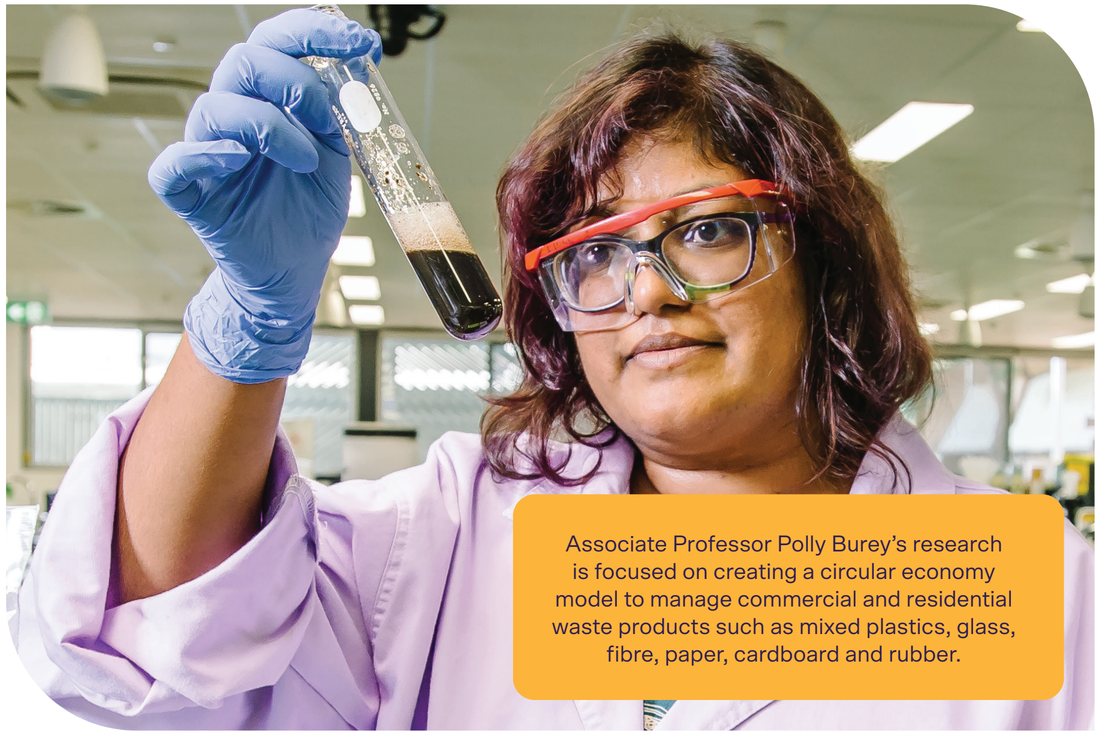
Food, Plant Agriculture and Packaging Valorisation

The University's Food Waste Valorisation Research Team focuses on the development of useful products and energy offsets from food excess and processing by-products, specifically ingredients, nutritional products, and composite materials, including bioplastics.

The team works with food and processing industries to analyse supply systems and determine economically and environmentally viable by-product transformation strategies and processes.

Research Capabilities

- **Circular economies** from supply chains to supply loops.
- **Food excess and by-products value-adding:** Preventing food waste through transformation into high value nutritional products, and novel longer-life products.
- **The use of whole of supply chain sensors and automation** to monitor product quality and trigger diversion pathways to prevent waste.
- **Development of new packaging pathways** to prevent landfill, and artificial intelligence auto-sorting at disposal.



Associate Professor Polly Burey's research is focused on creating a circular economy model to manage commercial and residential waste products such as mixed plastics, glass, fibre, paper, cardboard and rubber.

Research Projects

NO WASTE

The University's New Options for Waste and Saving The Environment (NO WASTE) Precinct project is supported by $2 million in funding from the Australian Government's Strategic University Reform Fund (SURF) to reduce the large amount of waste that ends up in landfill.

The NO WASTE Precinct project is implementing a circular economy model to identify the best ways to make commercial and residential recycling and upcycling viable and profitable.

The precinct is based in Toowoomba and will work with local retail entities, manufacturing industries, technical specialists and education providers, in Toowoomba and Ipswich, to revitalise existing recycling programs.
The project will operate as a regional test case to develop general waste reduction initiatives and build a more efficient industry that is scalable and transferable into other local communities; further strengthening the University's link to our local communities.

Preventing Queen Garnet Plum Waste

The Queen Garnet (QG) is a unique variety of plum developed in Queensland and sold by Nutrafruit at a premium due to the QG's higher antioxidant content compared to other plum varieties.

In 2020, 20 per cent of the fruit was composite, lower-grade fruit sent for processing, however, some still ended up in landfill. Nutrafruit's business plan is to expand its reach by spreading awareness of the benefits of the QG plum and grow the product market so this surplus fruit can be used.

Nutrafruit is working with University researchers to understand more about the health benefits of the QG plum, and how to maximise the anthocyanin concentrations in the fruit and associated value-added products through a project funded by the Fight Food Waste Cooperative Research Centre.

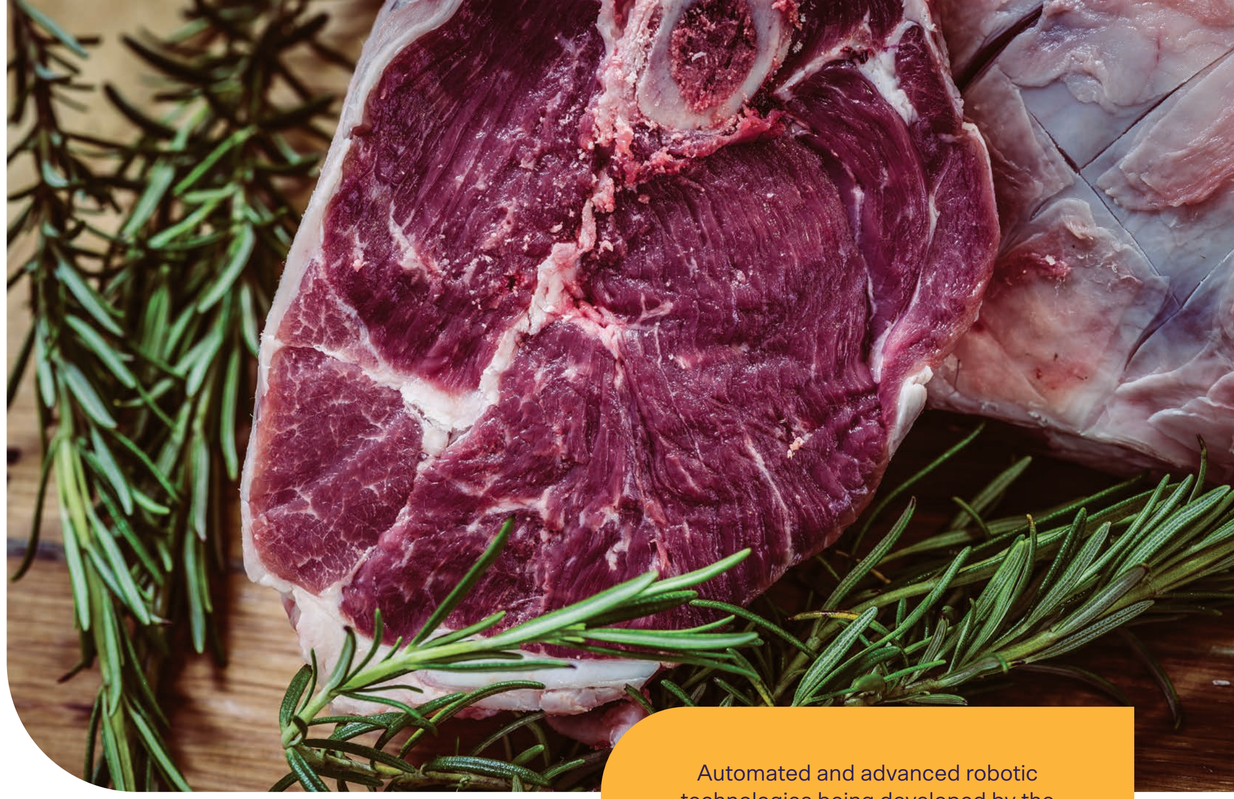
University staff will also upskill Nutrafruit's process and technical staff and product development team in how to track the nutrient content of the QG plum through the supply chain.

Agricultural Engineering: Robotics, Automation and Machine Vision

The University's Robotics, Automation and Machine Vision Research Team in the Centre for Agricultural Engineering deliver innovative automation technology that is revolutionising agricultural and food production practices.

The team develops integrated advanced robotic sensing technologies that enhance autonomy in crop production, biosecurity, livestock monitoring and the downstream processing of harvested produce. Through close collaboration with end-users in the field, research conducted by the team is adding advantage and value to modern commercial agricultural enterprises.

The Centre for Agricultural Engineering has a long history of developing technology solutions for the Agriculture sector.



Automated and advanced robotic technologies being developed by the University have the potential to benefit local industries working on a global scale.

Research Capabilities

- **Development of machine vision and sensing technologies** to distinguish weeds from crops, identify unhealthy crop areas and dramatically reduce the need for herbicides. This technology can also be applied to livestock to enable monitoring of condition and behaviour for health, breed, control and yield.
- **Automated agricultural technologies** such as driverless tractors to reduce labour costs and increase productivity.
- **Automated robotic meat** processing to consistently deliver high quality products within the food and meat processing industries.

Research Projects

Automation in livestock and meat processing industries

University research is transforming traditional primary industries with advanced technologies such as robotics and automation. An emerging area of work is exploring new techniques to minimise yield losses in the red meat processing industry through the utilisation of advanced sensing and imagery equipment. Research is being undertaken with industry partners to directly target the key issues facing Australia's $89 million meat processing industry.

Space Agriculture

Scientists from the Centre for Agricultural Engineering are working with NASA to extend fresh food options for astronauts during space missions by developing launch-ready software that will use machine vision to detect early stress in plants being grown on board space flights. Astronauts are currently supported nutritionally through food resupply missions, but this is difficult to maintain on deep space assignments.

The research project is developing monitoring algorithms to complement current sensing approaches used by NASA to advance sustainable plant-based food production in space. Robotic vision systems requiring minimal, or no crew interaction will monitor plants for signs of stress and will ultimately provide increased food safety and food options. This work transfers the University's existing expertise in the development of new machine algorithms for plant monitoring in broadacre cropping environments and at remote farm locations to space.

See & Spray™ Select

A collaboration between John Deere and the University of Southern Queensland has led to the development of vision-based precision spray technology for use on fallow ground that will reduce input costs and minimise environmental impact in farming businesses across the globe.

See & Spray™ Select uses integrated camera technology to rapidly detect green plants and automatically trigger an application of herbicide. It is available on new 400 and 600 Series Sprayers from John Deere, making it the industry's first factory-installed targeted-spray solution. The sprayer operator can switch from an effective targeted-spray solution to a highly productive traditional broadcast machine without leaving the sprayer cab, giving farmers two time-saving sprayers in one.

John Deere further developed and tested the technology across farms in the United States, Canada, and Australia before releasing See & Spray™ Select globally in 2021.

The initial experimental work to develop the vision-based plant detection technology in See & Spray™ Select was funded through a combination of industry research projects from Sugar Research Australia, Cotton Research and Development Corporation, Hort Innovation and the University.

Chicken Welfare Monitoring

Tracking flock growth, behaviours and welfare in a commercial shed environment is a manual process for meat chicken farmers. Producers generally catch and weigh birds to monitor growth and visual inspection is the norm for behavioural and welfare checks.

AgriFutures Australia and the University have developed a novel video analysis software and hardware prototype which uses artificial intelligence and enables indicators of flock welfare to be compared objectively between flocks and farms, providing opportunities for enhanced management decisions.

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