Final Project Summary

P9c: Adding value to dairy waste

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What a waste

In Australia, about 16% (equivalent to 1,300,000 tonnes/year) of total on-farm milk production is discarded as waste. Most of this wastage occurs post farm gate, for example at processing, distribution, food service and consumer stages of the supply chain.

The effect of this wastage is not just economic; it also has an impact on the environment and food security.

Although some efficiency could be gained by reducing total waste, it is also possible to turn what would be wasted into a valuable product. For example, dairy waste can be recycled and repurposed using existing methods such as reverse osmosis, drying, hydrolysis, ultrafiltration, and electrodialysis.

Fermentation

The Dairy UP team investigated fermentation opportunities to convert dairy wastes into value-added products with an existing commercial market. Fermentation uses microbes such as yeasts to convert dairy wastes into valuable products.

Fermentation can be cost-effective, can generate new income streams for farmers and processors as well as reduce waste.

Fermentation can produce a range of compounds, including stockfeed supplements.

Getting more from milk

Milk underpins the dairy industry. Getting more from this precious commodity has the potential to increase its value throughout the supply chain.

The Dairy UP team investigated novel ways to get more value from milk.

There were three elements to this research:

- P9a: Producing milk with less lactose
- P9b: Milk as an indicator of heat load
- P9c: Adding value to dairy waste

This document provides an overview of P9c.

Key findings

Fermentation is feasible

This work confirmed that microbial fermentation of dairy food waste streams at the manufacturer level, could be a practical pathway to generate value-added products, reduce waste disposal costs, and create new revenue streams. This is particularly the case for cheese whey and whey -derived byproducts. For processors currently spending significant resources on waste management, even partial use of these streams could significantly improve the economics of waste handling.

From an environmental perspective, converting dairy food wastes into useful products reduces the volume requiring disposal and lowering associated greenhouse gas emissions, water use, and environmental compliance costs. This approach directly supports the circular economy principles that are increasingly expected by regulators, retailers and consumers in Australian and overseas markets.

Overcoming a technical constraint

In the laboratory, the team identified a technical constraint: standard yeast strains are unable to

metabolise lactose. To address this, they were able to engineer a food-grade yeast strain capable of growing on lactose and producing provitamin A. The strain also demonstrated growth on 50% milk medium supplemented with lactose, confirming feasibility of fermenting dairy food waste. While currently at laboratory scale, this established a functional platform for further development.

Application
Significant technical and economic development is required before commercial application; however, the work establishes a clear foundation and a defined set of next steps toward scalable bioproduction from Australian dairy food waste.

More info

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Research and results

The project aimed to:

- **Identify opportunities** by reviewing and mapping dairy food waste streams in Australia and overseas and consulting with industry stakeholders to determine those with the greatest opportunity for reduction.
- **Investigate microbial fermentation** options for adding value to dairy food waste.
- **Pilot/proof-of-concept studies** to develop yeast strains capable of producing valuable compounds from dairy waste.

Fermentation opportunities

The review confirmed that dairy food waste streams are well suited to bioproduction in terms of volume, composition and consistency. This supports the case for investment in this approach, as a practical circular economy strategy. The two biggest opportunities for using fermentation to add value to dairy food waste identified were in the manufacturing sector and on farm.

On farm
Although dairy food waste on farm represents only about 1% of the total, a significant proportion comprises milk with antibiotics fed to calves. This represents a potential risk and opportunity for further investigation. For example, waste milk could be used to produce microbial protein (also called single-cell protein) as an animal feed or ration additive to improve digestive efficiency. It may also be possible to use yeast to degrade antibiotics present in waste milk and then feed the antibiotic-free milk or by-product to calves, thus preventing the development of antibiotic resistance.

Manufacturing
Manufacturing waste makes up 70% of all dairy food waste in the supply chain (Dairy Australia, 2023).

Cheese whey and derived by-products were identified as the most suitable streams for microbial fermentation. They are produced in concentrated and relatively consistent volumes at manufacturing facilities, making them more amenable to scalable bioproduction than household or food service waste, which is compositionally variable and logistically dispersed.

Yeasts

The Dairy UP team focussed on fermentation using brewer's or baker's yeast (*Saccharomyces cerevisiae)* which is safe for humans and animals. Yeast is already widely used for fermentation, so processes and equipment are readily available. There are also existing paths to market for the end products.

Lactose is a key component of dairy wastes, so the focus was on developing yeast that can grow on lactose. The team identified opportunities to use yeast fermentation of lactose in dairy waste to produce:

- Functional milks that are high in specific compounds that could be used as dietary supplements in the cow's diet.

DairyUP
Unlocking potential

- Enzymes and binders that reduce human and animal health risks such as mycotoxins in stockfeed.
- Enzymes and organic acids that improve stock feed quality.
- Supplements that optimise cow nutrition (e.g. proteins, amino acids and probiotics).
- Production of ethanol as a biofuel.

Determining viability

Researchers at Macquarie University's Genome Foundry used state-of-the-art synthetic biology technology to develop a yeast capable of efficiently fermenting lactose to produce valuable compounds.

As a proof-of-concept, yeast strains were engineered to produce provitamin A from lactose. Provitamin A is a precursor of vitamin A, has antioxidant properties and is widely used as a dietary supplement for humans and stockfeed.

The research identified a key technical constraint in that standard yeast strains (e.g. *S. cerevisiae*) are unable to metabolise lactose. Alternative species, such as *Kluyveromyces marxianus*, offer partial solutions but present performance and regulatory limitations. Engineered *S. cerevisiae* strains can overcome this constraint but require further optimisation for industrial-scale efficiency.

A food-grade yeast strain capable of growing on lactose and producing provitamin A was successfully engineered. The strain also demonstrated growth on 50% milk supplemented with lactose, confirming feasibility of fermenting dairy food waste. While currently at laboratory scale, this established a functional platform for further development.

The proof-of-concept demonstration of growth on lactose substrates and production of a nutritionally relevant compound provides the evidence base required to justify further investment in scale-up and techno-economic evaluation.

Read more

www.dairyup.com.au

P9 final report

Dairy Australia 2023; Dairy sector food waste action plan.

J.I. Gargiulo, et. al. INVITED REVIEW: Turning Dairy Food Waste into Valuable Products via Yeast Bioproduction, Journal of Dairy Science, 2026

Collaborators

The P9c project was a collaboration between Dairy UP, NSW DPIRD, Macquarie University's Australian Genome Foundry and the University of Sydney.

Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries and Regional Development | Scibus | Dairy Australia

Partner organisations

NSW Growing the best | eastAUSmilk | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

Additional program supporters, collaborations or partnerships

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