# Overview: Research priorities in fermentation

*Fermentation allows the production of proteins, fats and functional ingredients using microorganisms.*

*Biomass fermentation grows and uses the whole organism as a source of protein, while precision fermentation uses microbes to produce specific functional ingredients for many foods including alternative proteins. These ingredients can address key functional and sensory challenges faced by plant-based or cultivated meat. Although fermentation is a relatively mature platform, using it in the context of alternative proteins presents new challenges.*


## Key research priorities for fermentation:

**Target identification and validation** to broaden the scope of food ingredients produced by precision fermentation and unlock new experiences for consumers.

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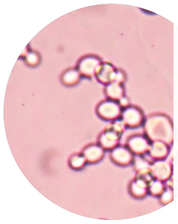

**Screening and optimisation of novel strains** to identify the most efficient pathways for producing targets and introduce greater robustness to manufacturing processes.

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**Unlocking alternative feedstocks** by leveraging existing agricultural and food processing waste streams to cut costs, reduce waste, and improve sustainability.

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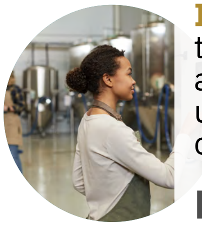

**Improved bioprocess design** to increase titers and yields, achieve more efficient scale-up, and drive down operating costs across the sector.

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# Deep dive: research priorities in fermentation

## Target identification

Fermentation is a key enabling technology for optimising the nutrition, taste, cost, and sustainability of alternative protein products. Success in target selection depends on target functionality, food applications and regulatory oversight. Methods for producing and encapsulating fats and oils similar to animal fats hold the key to bridging the taste gap between plant-based and animal-based meats and can provide a source of nutritionally important omega-3 fatty acids, particularly for seafood alternatives. Traditionally these targets require downstream processing technologies for efficient extraction of shelf-stable lipids, but encapsulation within the microbes themselves is a promising emerging solution.

Other areas which merit further attention include recombinant proteins like heme to improve the taste and “meatiness” of plant-based proteins or volatile compounds that improve aroma. Developing trends include developing neutral colour and mild flavour protein ingredients, the manufacture of affordable growth factors for use in cultivated meat production, and adding bioavailable nutrients to foods that would otherwise be lacking. Researchers can accelerate the design of new targets by using AI-backed machine learning to predict protein structure and function. Research on allergenicity and food formulation to inform safety assessment will also be valuable in evaluating precision fermentation-made products.

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## Screening and optimisation of novel strains

Microbes offer immense biological diversity which can be leveraged to identify or create strains with enhanced growth potential, nutritional characteristics, flavour profiles, or feedstock preferences. Strain development focuses on bringing out the best features of a particular microbial strain, maximising productivity and minimising undesirable qualities. In precision fermentation, biosynthetic pathway discovery can elucidate the pathways responsible for producing desired molecules and inform strategies for designing microbial strains that produce targets at scale. To broaden the spectrum of available microorganisms, systematic investigation into the physiology of novel microbial strains is needed.

Strain development also has an important role to play in biomass fermentation. Suppressing hyper-branching of filamentous fungi is a key challenge in achieving efficient continuous cultivation which could greatly increase bioprocessing efficiency and reduce costs. Single-cell protein products are widely produced as animal-feed products but often lack the functionality and organoleptic characteristics required for human consumption. Research should focus on approaches to improve the quality of these products. A better understanding of available food-safe selection markers as well as efforts to develop new selection markers to encourage strain development will be important.

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# Deep dive: research priorities in fermentation

## Feedstock optimisation

In fermentation, feedstocks refer to the predominant raw materials used as a source of energy for microorganisms to grow and produce a range of bioproducts. Sourcing alternative feedstocks can cut costs, reclaim or repurpose food waste, and improve the sustainability of alternative protein production. Most fermentation bioprocesses rely either on glucose derived from hydrolysis of starch or sucrose extracted from crops like sugarcane. Alternative feedstocks remain highly inconsistent and poorly characterised. There is therefore a major requirement for research and development efforts which focus on optimising, valorizing and diversifying feedstock sources, in combination with strain development.

A shift toward more diverse feedstocks will require widely-adopted ingredient standards and comprehensive methods for feedstock characterization. Optimisation of processing conditions for maximised recovery of high-value ingredients from sources such as plant biomass and food byproducts, alongside improvements in drying and stabilisation and evaluation of their safety for use in food production, are critical. Diversification beyond sugar feedstock by using novel microorganisms that grow on other carbon sources like waste gases is another important trend. For all of these processes, life cycle assessments and techno-economic analyses will be required.

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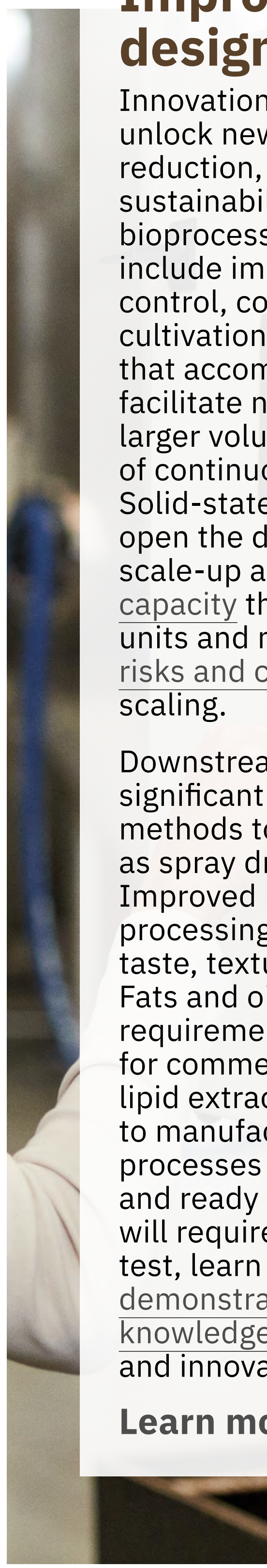

## Improved bioprocess design

Innovations in bioprocess design can unlock new opportunities for cost reduction, scale-up, and environmental sustainability. For upstream bioprocessing, research priorities include improvements to monitoring and control, continuous processes, and co-cultivation systems. Bioreactor designs that accommodate more viscous cultures, facilitate nutrient and air exchange at larger volumes, or enable longer periods of continuous production, are needed. Solid-state fermentation platforms also open the door to scale-out rather than scale-up approaches by increasing capacity through parallel small-scale units and mitigate some of the technical risks and capital costs associated with scaling.

Downstream processing can add significantly to operating costs so methods to reduce the cost of steps such as spray drying should be investigated. Improved biomass downstream processing can also unlock better taste, texture, and formulation options. Fats and oils have unique processing requirements which can be a bottleneck for commercialization so advances in lipid extraction are needed. The road to manufacturing readiness requires processes to be technologically mature and ready for deployment at scale and will require iterations of the design, build, test, learn cycle across the lab, pilot, and demonstration scales, as well as efficient knowledge sharing within the research and innovation community.

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