2026 STATE OF THE INDUSTRY:

Fermentation

for meat, seafood, eggs, dairy and ingredients

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About the series

The State of the Industry report series is GFI's annual deep dive into the rapidly evolving alternative protein landscape. This flagship series provides a global snapshot of the industry, synthesizing company landscape and product trends, investment and sales data, new scientific advancements, and public investment and regulatory updates that highlight industry progress.

Tracking the technological and adoption readiness of the cultivated, plant-based, and fermentation sectors is a useful method to evaluate progress toward competing on price, taste, and availability with conventional meat. Readiness can be determined by assessing the progress, challenges, and overall risk across categories such as scientific feasibility, engineering viability, innovation capacity, value proposition, market acceptance, and license to operate. This series summarizes the current state of these factors using real-world developments from the past year.

Access the full suite of 2026 State of the Industry reports here.

Important notes

- All figures are expressed in U.S. dollars where the $ symbol is used. Other global currencies are clearly marked.
- The Good Food Institute is not a licensed investment or financial advisor, and nothing in this report is intended or should be construed as investment advice.
- An update to the report titles: In past years, GFI titled each State of the Industry report with the year covered in report content. Starting in 2026, the report titles now reflect the publication year (content timeframe remains the same).

Editor's note

Fermentation—a process used to make food for millennia—is an emerging production method of choice for those striving to satisfy growing demand for meat in new, more sustainable ways.

Among those striving are governments, companies, and researchers who recognize the need to diversify protein production on a planet being pushed to its limits. If we are to meet growing global demand for meat while addressing some of the world's biggest challenges within the next two critical decades, we can't simply ramp up business-as-usual meat production. While multiple interventions will be needed, fermentation-derived meat—as well as cultivated and plant-based meat—is an essential globally scalable solution.

Over the last decade, fermentation-enabled protein production has evolved rapidly, from a niche concept to a global food solution deeply integrated with plant-based and cultivated meat innovation. In 2025, the field experienced both challenges and breakthroughs:

- A handful of high-profile closures and restructurings drew headlines asking questions about scale-up pathways as regulatory wins continued to quietly rack up. Several companies achieved regulatory approval in the United States and China.
- While the tightening funding environment proved challenging, significant investments were made to support commercialization and market rollout.
- Questions about profitability surfaced, while new commercial locations increased production capacity, incumbents utilized partnerships to de-risk scale up, and cost modeling clarified the path to price parity.

Then and now: Ten short years ago, the milestones of today in fermentation-derived proteins may have seemed far-fetched. It can be grounding to stop and ask: how far have we come in a decade?

In 2015, fermentation was mainly used to make inputs and ingredients for food and industrial products, like enzymes and additives. By 2025, it was producing bioidentical animal proteins and functional ingredients like vitamins, flavors, and fats. In the past year, corporations and startups partnered to advance ingredient, process, and product innovation; new facilities opened around the world to pilot and cross-pollinate techniques; several mycelium-based products launched in the United States and Europe; and fermentation increasingly featured in public investments aimed at strengthening the bioeconomy.

Today, fermentation-derived innovators focused on meat, seafood, eggs, dairy, and ingredients are zeroing in on the fundamentals of production—bringing down costs, optimizing taste and texture, and minimizing environmental impacts.

And focus we must. Evidence that existing meat production exacerbates global challenges—from climate change to pandemic risk—is mounting. In December 2025, the UN Environment Programme published the Global Environment Outlook, 7th Edition. The report notes that alternative proteins have the potential to pay significant dividends for our environment.

But we're not in the clear yet. This report, Fermentation for meat, seafood, eggs, dairy, and ingredients, details year-over-year funding declines, technical and cost hurdles, and regulatory challenges.

But the following pages also shine a light on the less visible progress: research collaborations, publicly funded infrastructure, and product launches like whole-cut meats with improved texture, reflecting an increasingly diversified and expanding sector.

At GFI, a nonprofit funded by philanthropy, we're committed to charting a path forward that feeds growing global demand for meat in restorative, resilient ways. Our annual State of the Industry series—including this report—equips food system stakeholders with knowledge of the innovations and developments that got us further down that path in 2025.

Thank you to all those who are in this work alongside us, and as such, helping to build a thriving world, fed sustainably.

3D-printed salmon filet made from mycoprotein. Photo credit: Reno Foods GmBH

Executive summary

In 2025, the fermentation-enabled protein and ingredients sector experienced a mix of successes and struggles across the commercial, investment, technology, policy, and regulatory landscape. Major themes:

- **New product launches, innovation, and regulatory wins.** The sector saw new product launches across meat, dairy, and ingredients, plus regulatory milestones in China and the United States. In 2025, more than 163 specialized companies and a growing number of research institutions kept innovating and optimizing fermentation-derived products so consumers can enjoy the foods they love made with a lighter footprint.
- **The funding environment tightened.** Fermentation funding was down year-over-year. Companies operating primarily in the fermentation ecosystem raised $357 million in 2025, according to GFI analysis of data from Net Zero Insights (down from $651 million in 2024).
- **Production quantities are increasing and food biomanufacturing is scaling.** Facilities opened around the world to pilot, accelerate, and cross-pollinate techniques. New commercial-scale locations opened in Brazil, Canada, China, Sweden, and the United Kingdom. Several companies validated circular feedstock strategies under commercially relevant conditions.
- **Public investment for fermentation-related research and commercialization is expanding.** Governments concerned with supply chain constraints and product shortages are recognizing precision fermentation for its ability to produce specific animal proteins, like those found in dairy and eggs. Many governments—in China, the EU, India, and more—implemented wide-ranging biotechnology plans, recognizing the potential benefits to the economy, food system, and national security.

	Bright spot	*Challenge*
Commercial landscape	**Harnessing knowledge from large companies for the benefit of startups:** Partnerships with key dairy, meat, fungi, grain, and yeast makers are enabling synergies and helping grow fermentation ingredient, process, and product pipelines. In this space, startups benefit from corporations' long-time expertise in industries such as dairy, and together they build on existing knowledge to maximize viability and efficiency.	**Product availability varies across different types of fermentation-derived products:** Products made from biomass fermentation are more widely available than products made from precision fermentation.

	Bright spot	*Challenge*
Investments	**Europe's fermentation ecosystem gains momentum:** Europe is positioning itself as a strategic hub for fermentation and the broader bioeconomy by leveraging public and industry investment in infrastructure, production assets, and regulatory and permitting pathways.	**All eyes on market performance:** A handful of high-profile closures and restructurings in 2025 tested assumptions around timelines, scale-up pathways, and downside risks. These sharpened investors' focus on unit economics, sustainable demand signals, and credible paths to profitability.
Science and technology *Scientific feasibility*	**Advancing mycoprotein strains to improve productivity and quality:** Efforts to improve the longstanding mycoprotein species used in **Quorn** products accelerated in 2025. A research collaboration between **NIAB** and **Marlow Foods** (Quorn's parent company) has identified important steps toward improved strain stability, productivity, and quality at scale.	**Data standardization is needed:** Bioprocesses could be ripe for AI/machine learning (ML) process optimization. However, data standardization is needed to enable cross-sector developments over siloed in-house solutions.
Engineering viability	**Continuous fermentation systems mature:** A major signal this year came from **Pow.Bio**, in collaboration with **Bühler**, who demonstrated scalable, transferable continuous fermentation of high-value dairy proteins at 3,000-liter scale with **ATV Technologies.** The scale up achieved over threefold productivity gains and a 50 percent reduction in costs, enabled by Pow.Bio's patent-pending continuous process technology and ML–based bioprocess control platform.	**Further precision fermentation modeling is needed:** Despite progress in benchmarking production costs, further precision fermentation modeling is needed to assess cost-reduction strategies, such as continuous processes for protein production.

	Bright spot	*Challenge*
Innovation capacity	**Expanding publicly funded infrastructure:** Newly launched and expanding research centers and facilities are strengthening translational, scalable innovation. Publicly funded infrastructure plays a key role in de-risking process development and scale up for fermentation-derived products.	**IP disputes signal commercialization risk:** Recent years have seen multiple high-profile disputes in fermentation-derived products. Often, prolonged legal proceedings coincided with major business disruption or even company closures. While company exits occur in competitive markets, protracted IP conflicts around foundational technologies risk slowing sector-wide scaling.
Government and regulation	**Legislation to support innovative food products:** In December 2025, South Korea enacted the Food Tech Industry Promotion Act, establishing a legal and administrative framework for the Ministry of Agriculture, Food, and Rural Affairs (MAFRA) to support innovative food products, including fermentation-enabled products. The Act empowers MAFRA to provide direct support to businesses, offer startup assistance, facilitate access to research facilities and equipment, foster market entry, and enable co-navigation of regulatory processes.	**Banning meat-related terms for alternative proteins in Europe:** Following several months of debate and negotiations in 2025, EU policymakers agreed in March 2026 to ban the use of the word “meat” and 31 meat-related terms for fermentation-enabled, plant-based, and cultivated options, despite consistent survey results demonstrating that European consumers support the use of these terms for plant-based products.

Conclusion

The fermentation field is diversifying and expanding, with many industry players now focused on scaling. Public and private investments in R&D and manufacturing are still being made, but not at levels sufficient for continued innovation and commercial scale up. Several companies reached important food biomanufacturing scaling milestones, but IP conflicts around foundational technologies and labeling restrictions risk slowing sector growth. Many governments are prioritizing fermentation-enabled proteins in their national food strategies to achieve a range of goals, from climate mitigation and food security to economic competitiveness and public health.

The underlying case for fermentation-enabled protein is stronger than ever: rising demand for meat, climate and land use pressures, and the need to diversify protein supply chains. To fully realize the planetary and public health benefits that come with mainstream adoption of fermentation-enabled meat and other alternative proteins, governments, industry, and the research community must prioritize support for innovation that can help these new foods reach more plates.

Commercial landscape

Overview

The fermentation sector continued to diversify and expand in 2025. Industry players focused on innovating and scaling, and several achieved regulatory approval in the United States and China while others continued to work toward this goal.

Several forms of fermentation (see box below) are being harnessed to produce alternative protein products and ingredients. In 2025, some companies pursued advancing biomass fermentation to further develop analog meat formats like whole-cut steaks and filets with improved texture.

Several mycelium-based products launched in the United States and Europe, while new facilities and collaborations popped up globally to scale production.

Precision fermentation is an attractive technology for its ability to produce specific animal proteins, like those found in dairy and eggs, critical during supply chain constraints and product shortages. This opportunity propelled several new partnerships in 2025 between conventional milk and alternative dairy makers, advancements in precision fermentation-enabled egg products, and prioritization of high-value ingredients as a strategic opportunity for select companies in an overall constrained funding environment.

Understanding fermentation

Traditional fermentation has been used for thousands of years to produce familiar products such as bread and beer. It uses intact, live microorganisms to modulate and process plant-derived ingredients, resulting in products with unique flavors, nutritional profiles, and textures. Examples include using the fungus *Rhizopus* to ferment soybeans into tempeh and using various lactic acid bacteria to produce cheese and yogurt. Traditional fermentation can improve the sensory, functional, and nutritional attributes of many alternative protein ingredients.

Biomass fermentation leverages the high-protein content and fast growth of microorganisms to produce large quantities of protein efficiently. Biomass fermentation offers the greatest opportunity to produce protein at scale, owing to the ability of many microorganisms to grow quickly, often doubling their weight in just a few hours. Microbial biomass can be the main ingredient of a food product or serve as one of several ingredients in a blend. A range of microorganisms is being explored for their applications in biomass fermentation, from yeast to filamentous fungi to microalgae.

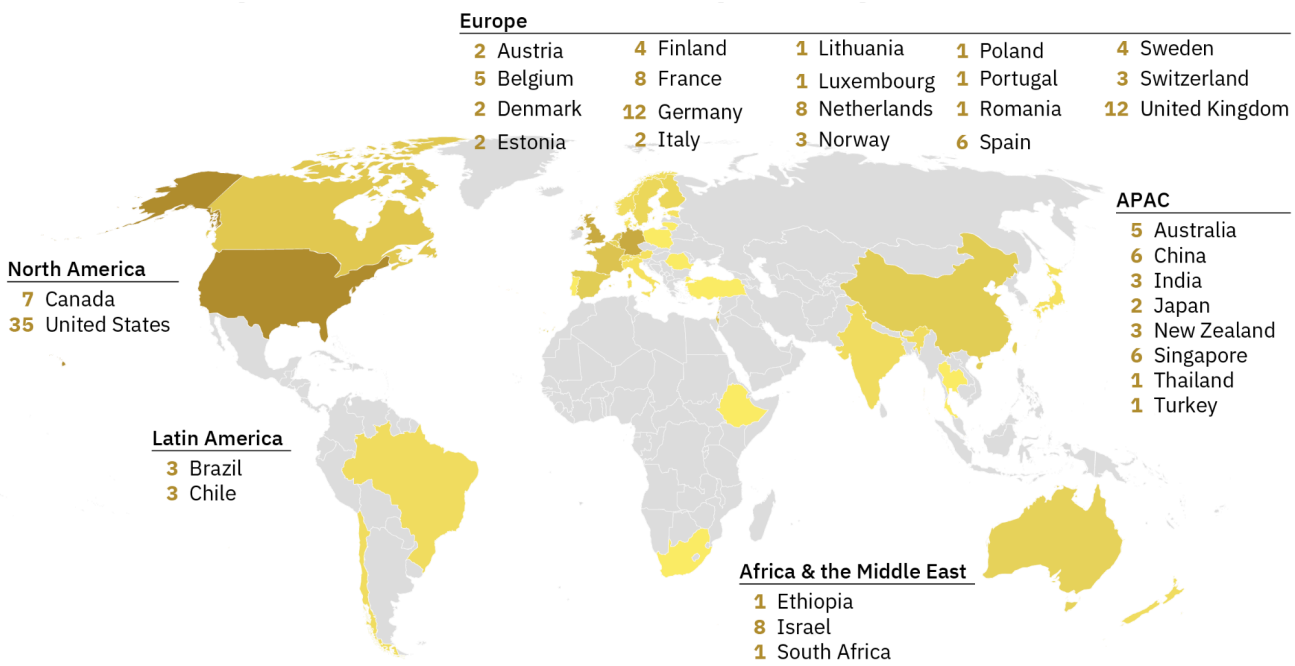
Precision fermentation is a form of specialized brewing that uses microbes to efficiently produce specific functional ingredients. Capable of producing proteins, vitamins, enzymes, natural pigments, and fats, precision fermentation is well-positioned to create high-value ingredients that improve the sensory characteristics and functional attributes of plant-based products or cultivated meat. It can be used to make egg proteins, dairy proteins, animal-free meat proteins, heme, and fats.

Company landscape

- **Number of companies:** In 2025, GFI's company database included 163 companies focused primarily on fermentation for alternative proteins.

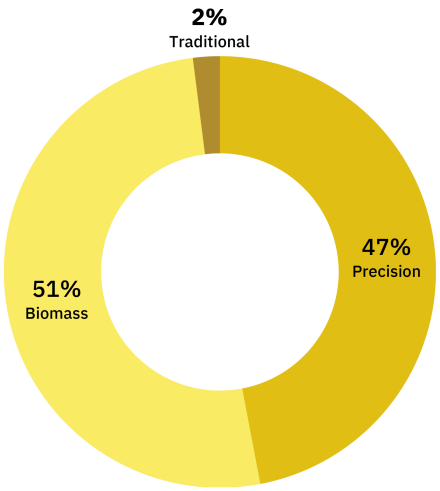
Additionally, at least 267 companies had some involvement in the industry through investments, partnerships, or business-to-business (B2B) product/service offerings, up from 210 in 2024.

Figure 1: Distribution of specialized fermentation companies by location



Source: Good Food Institute, Alternative protein company database, accessed: December 10, 2025. Specialized companies include (1) companies primarily or solely focused on producing fermentation-enabled meat, dairy, seafood, or egg analogs or (2) companies with a significant or sole focus on serving the alternative protein industry with ingredients or equipment. To avoid double counting companies across alternative protein sectors in the State of the Industry reports, companies involved in multiple alternative protein platforms are categorized by the platform they are most involved in (e.g., plant-based, fermentation). These restrictions do not apply in GFI's alternative protein company database.

Figure 2: Percentage of companies involved in each technology focus area



Source: Good Food Institute, Alternative protein company database, accessed: December 10, 2025.

Note: Involvement by technology focus area is determined by a company's categorization in GFI's Alternative protein company database. Company representatives can self-select their company's focus area(s), as can GFI team members.

Note: Figures 1 and 2 (above) and Table 1 (below) may not reflect the full alternative protein commercial landscape in Japan. Some private sector companies in Japan prefer not to be included in public industry lists for underdeveloped products.

Facilities

Facilities opened around the world to pilot, accelerate, and cross-pollinate techniques. New commercial locations also opened to increase production quantities.

Pilot-scale facilities

- **Australia:** With an AUD 18 million ($13 million) investment from the governments of Australia and Queensland, the **Queensland University of Technology** upgraded an existing facility into a food-grade, pilot-scale fermentation facility.
- **China:** The **Fengtai District government** and meat processor **Shounong Food Group** teamed up to open the New Protein Food Science and Technology Innovation Base, a hub intended to accelerate development of cultivated and fermentation-enabled protein production.
- **Sweden: Tetra Pak** opened a new pilot plant to support the scale up of foods made using biomass and precision fermentation.
- **United States: Pow.bio** opened a new facility designed for food producers to showcase, develop, and scale up precision fermentation-enabled products using AI. The food industry systems supplier **GEA** established a $20 million tech center in Wisconsin to help the alternative protein industry scale up plant-based, fermentation, and cultivated technologies.

Commercial-scale facilities

- **Brazil:** The startup **Typcal** opened the first industrial-scale fermentation facility in Latin America dedicated to producing mycelium-based proteins.
- **Canada:** A new 50,000+ square-foot facility in Nova Scotia, built for commercial-scale fermentation and supported by a public-private partnership, aims to grow the local biomanufacturing sector.
- **China:** The biotech company **Angel Yeast** completed construction of a new industrial facility that will increase their ability to produce protein from yeast.
- **Sweden:** The food tech firm **Millow** announced the completion of their first full-scale production facility for their patented fermentation process using mycelium and oats.
- **United Kingdom:** Food tech startup **Clean Food Group** acquired a one-million-liter production facility to scale up production of their precision fermentation-derived oils and fats.

Involvement by diversified companies

Table 1. Diversified company involvement in fermentation

New in 2025

Company	Investment	Acquisition	Partnership	R&D and manufacturing
ABInBev	✓		✓	✓
Alfa Laval				★
Bel Group			✓★	✓★
Bühler Group			★	★
Cargill			✓	
Cheil Jedang Corp.			✓	
Danone	✓			✓
Fonterra			✓	
Friesland Campina				✓
GEA Group			✓	✓★
General Mills			✓	✓
Hormel Foods			✓	
Kraft Heinz	✓			
Leprino Foods			✓	
Maple Leaf Foods	✓		✓	
Nestlé	✓			✓
Pulmuone			✓	
Tyson Foods	✓			
Unilever			✓	✓

Source: GFI analysis of publicly reported industry news and events. Featured companies are selected based on the following criteria:

- Food-focused: food manufacturing is a core segment and/or revenue driver
- Diversified: operating in multiple categories or having multiple business units
- Geographic reach: operating in multiple regions and/or countries
- Having publicly documented activity in the alternative protein industry

New partnerships

Partnerships with key dairy, meat, fungi, grain, and yeast makers are enabling synergies and helping grow and build fermentation ingredient, process, and product pipelines. In this space, startups benefit from corporations' long-time expertise in industries such as dairy and together they build on existing knowledge to maximize viability and efficiency.

Incumbents use partnerships to de-risk precision fermentation scale up

Europe

Precision fermentation startup **Standing Ovation** partnered with the corporation **Ajinomoto Foods Europe** to produce their animal-free milk protein at scale. Standing Ovation also began collaborating with **Bel Group** to upcycle whey to make casein using precision fermentation, as well as working with **Tetra Pak** to streamline production. The Swedish startup **Melt&Marble** is partnering with the Finnish food corporation **Valio** to develop plant-based meat and dairy products made with fermentation-derived fats for improved taste and texture.

India

Perfect Day and **Zydus Lifesciences** have partnered via a joint venture to build a precision fermentation facility for recombinant whey proteins, aiming to start operations in 2026 with a controlled capacity scale up into 2027.

South Africa, United States, Australia, Europe

Joint ventures emerged between **DeNovo Foodlabs** and **Earth First Food Ventures Ltd** and between Australian biotech company **All G** and French bioactives supplier **Armor Protéine** to scale production of lactoferrin, a protein found in breast milk and prized for its immunity and gut health benefits.

Industrial and manufacturing players emerge as key enablers

- **Europe:** Swiss manufacturing giant **Bühler Group** collaborated with U.S. firm **Pow.Bio** to launch an AI-led continuous precision fermentation technology. Biotech startup **Cultivated B** and conglomerate **Siemens** collaborated on a bioreactor intended to help scale fermentation-derived proteins.
- **Denmark and United States:** The Dutch precision fermentation company **Vivici** is teaming up with **Liberation Labs** to manufacture their precision fermentation-derived dairy protein in the U.S. for use in protein drinks, powders, and bars.

Cross-sector collaborations accelerate ecosystem development

- **Denmark and United States:** Backed by **Alfa Laval**, the **Danish Technological Institute** and **North Carolina State University** began a collaboration to advance precision and biomass fermentation by leveraging industry, academic, and government resources between the two regions, both recognized as leaders in food innovation.

Product launches

Both consumer package goods (CPGs) and startup companies appear in the list of top 2025 product launches, with the majority based on biomass fermentation. Launches span meat, dairy, and protein ingredients in retail and foodservice.

Biomass fermentation

- **Europe:** Following their foodservice launch earlier this year, Swiss startup **Planted** launched fermentation-enabled steak bites at retailers in Switzerland and Germany. They also launched mycoprotein-based schnitzel, burgers, and nuggets in German and Austrian retail. Also in German and Austrian retail, **Revo Foods** launched a 3D-printed salmon filet made from mycoprotein using technology that could be applied to other seafood formats. **Aldi Suisse** launched a private-label mycoprotein-based chicken filet made by Swiss-based biomanufacturing firm **Planetary**.
- **North America:** The European startups **Juicy Marbles** and **Revo Foods** joined forces to launch fermentation-enabled, whole-cut cod in the U.S. **Prime Roots** debuted their new line of Koji-based deli meats after several years of R&D, and expanded into Canadian foodservice. Chinese food tech company **CellEx** launched a new U.S. brand called **Mourish**, featuring a line of mycelium-based jerky. The startup **MyForest Foods** rolled out their mycelium-based bacon and pulled pork at **Whole Foods Market** locations. **Beyond Meat** rolled out a new whole-cut, mycelium-based steak filet in U.S. foodservice.

Precision fermentation

- **Middle East: Strauss Group** launched dairy-free milk and cream cheese in retail using fermentation-derived whey protein from **ImaginDairy**. In partnership with conventional dairy company **Gad Dairies**, startup **Remilk** released precision fermentation-enabled milk in cafes and restaurants.
- **United States: The EVERY Company** launched an undisclosed precision fermentation-derived egg protein product at **Walmart** stores throughout the country, with an announcement of their $55 million Series D round.

Scrambled eggs using EVERY OvoPro™. Photo courtesy of The EVERY Company

Investments

Overview

Companies operating primarily in the fermentation ecosystem raised $357 million in 2025, according to GFI analysis of data from Net Zero Insights. That brought the total capital invested in the sector since 2016 to $5.2 billion, $5.1 billion of which has been raised by privately held companies.

Key trends from 2025 include:

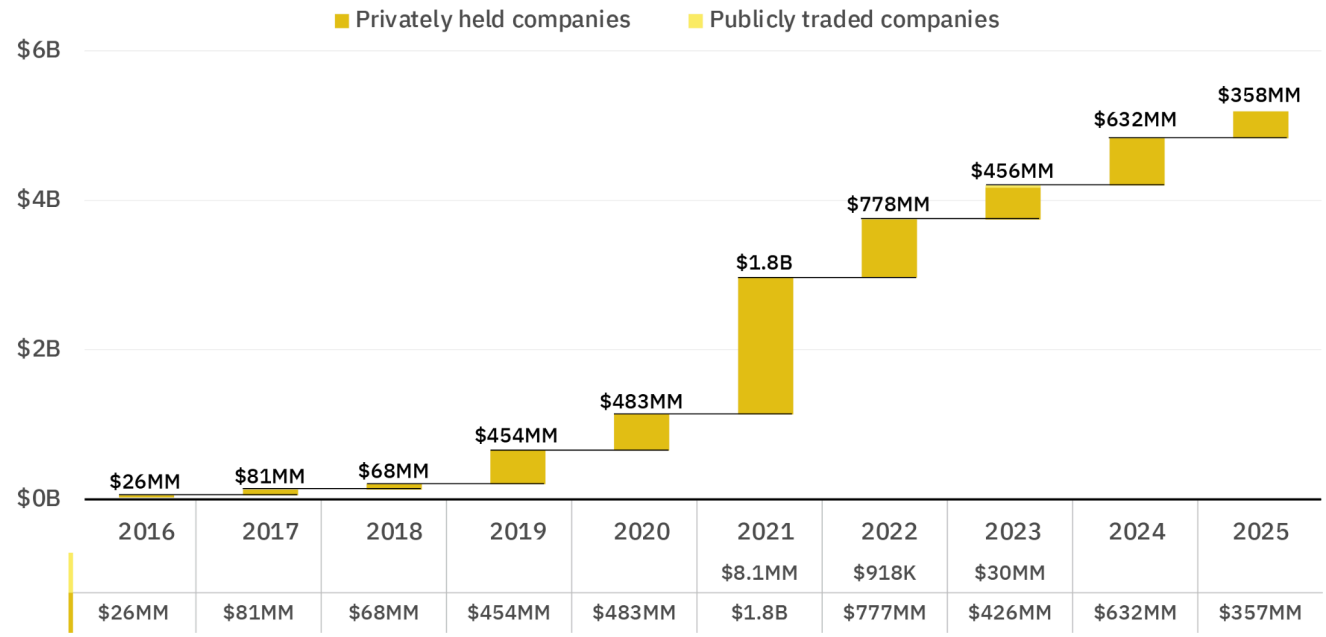
- **Bigger investments in commercialization:** The three largest fermentation deals in 2025 were **The EVERY Company**'s $55 million Series D, **Formo**'s $36 million venture debt loan, and **The Protein Brewery**'s $35 million Series B. All three deals were raised to support commercialization and market rollout. Earlier-stage companies with longer R&D horizons continued to raise capital, but generally at smaller ticket sizes than in recent years.
- **Public investment in the bioeconomy:** Fermentation increasingly featured in government- and development-finance-backed efforts to strengthen the biomanufacturing ecosystem. In the Middle East, the **Abu Dhabi Investment Office** partnered with **The EVERY Company** and **Vivici** to explore the establishment of a multi-tenant industrial-scale facility. In Europe, public and development finance actors supported multiple fermentation companies, including the **European Investment Bank**'s venture debt loan to **Formo**, **Invest-NL**'s participation in **Vivici**'s Series A and **The Protein Brewery**'s Series B, and $15 million from the **European Innovation Council** for **MOA Foodtech**.
- **All eyes on market performance:** While the fermentation sector did not see the same pace of consolidation as the plant-based and cultivated industries, a handful of high-profile closures and restructurings in 2025 tested assumptions around timelines, scale-up pathways, and downside risks. These sharpened investor focus on unit economics, sustainable demand signals, and credible paths to profitability, raising the bar for new financing across the sector.

The wider ecosystem of alternative protein companies raised $881 million in 2025, approximately 40 percent of which went to fermentation companies. Of that overall total, $734 million was raised by privately held companies and $147 million was raised by publicly traded companies. Since 2016, privately held companies in the sector have raised $16.7 billion, while publicly traded companies have raised $2.7 billion.

Broader private capital markets are increasingly dominated by investments in artificial intelligence (AI), which captured nearly 50 percent of all global funding in 2025. Venture capital tightened across most other sectors, and alternative proteins experienced similar barriers to raising capital as the broader climate tech and food tech spaces. The decline in fermentation investments in 2025 mirrored these pullbacks in adjacent sectors.

Investment in privately held and publicly traded fermentation companies

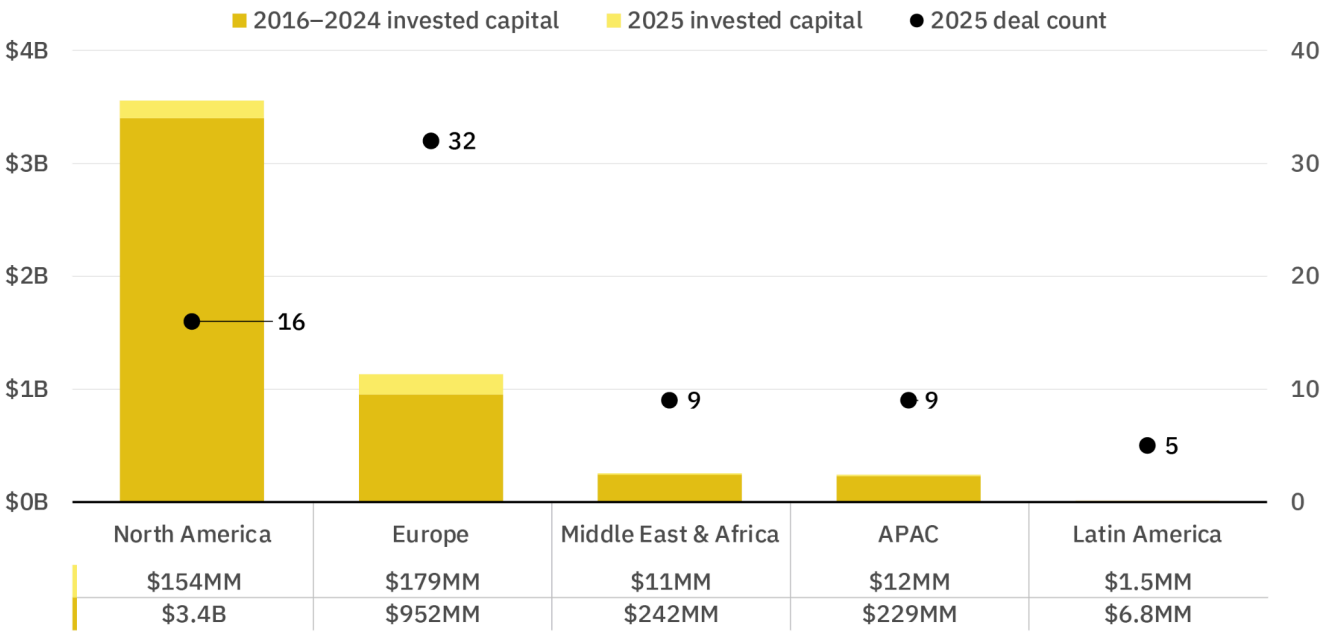
2016-2025



Source: GFI analysis of data from Net Zero Insights. Aggregated data has not been reviewed by Net Zero Insights analysts. Note: Fermentation totals include investments in both privately held and publicly traded companies.

Investments in fermentation companies by region

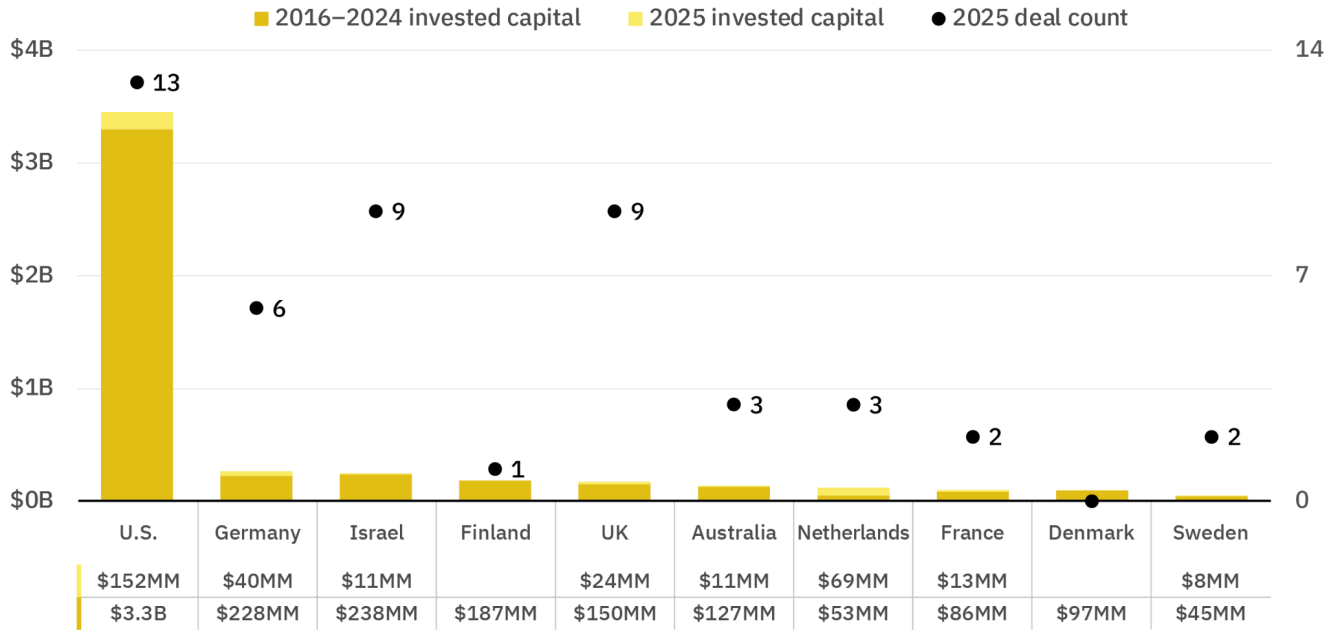
2016-2025



Source: GFI analysis of data from Net Zero Insights. Aggregated data has not been reviewed by Net Zero Insights analysts. Note: Fermentation totals include investments in companies focused primarily on plant molecular farming due to similarities in the types of ingredients they produce and in the downstream processing to obtain those ingredients from the host organisms. Fermentation totals include investments in both privately held and publicly traded companies.

Investments in fermentation companies: Top 10 countries

2016-2025



Source: GFI analysis of data from Net Zero Insights. Aggregated data has not been reviewed by Net Zero Insights analysts. Note: Fermentation totals include investments in companies focused primarily on plant molecular farming due to similarities in the types of ingredients they produce and in the downstream processing to obtain those ingredients from the host organisms. Fermentation totals include investments in both privately held and publicly traded companies.

2025 key funding rounds

Debt

Formo $36MM

MAIA FARMS $1.8MM

Series D

EVERY $55MM

Series B

The Protein Brewery $35MM

Series A

VIVICI $34MM

The Better Meat Co. $31MM

Convertible note

Liberation Bioindustries $32MM

all g foods limitlessly good $6.6MM

Late VC

MyFOREST foods $11MM

ORF GENETICS $5.9MM

Growth equity

Quorn $24MM

Early VC

Those Vegan Cowboys $7.3MM

PFS Biotech $7.3MM

Equity crowdfunding

FUTURE COW $219K

Debt crowdfunding

Pan's $71K

Seed

NUTROPY $8.2MM

BREVEL $5MM

asterix FOODS $4.2MM

Accelerator/incubator

FINALLY Foods $300K

$300K

updairy $300K

Source: GFI analysis of data from Net Zero Insights. Note: "2025 key funding rounds" includes investments in the 75th percentile or higher by dollar amount for each funding round category that includes more than three deals. For funding round categories that include three deals or fewer, all deals are included. Aggregated data has not been reviewed by Net Zero Insights analysts. The total deal count includes deals with undisclosed amounts.

A clearer funding pathway for upstream models

In a tighter funding environment, capital is increasingly flowing toward companies showing a credible path to near-term adoption. Upstream, B2B-oriented companies are relatively well-positioned in this context because customer validation can be demonstrated through letters of intent, strategic partnerships, and supply agreements. These signals reduce demand uncertainty, making commercialization timelines easier to underwrite.

Eight of the 10 largest fermentation deals went to companies operating across ingredients, manufacturing, equipment, and production technology. Together, those deals alone represented roughly 70 percent of the sector's total deal value for the year.

The rising share of precision fermentation investment also reflects this trend. Precision fermentation companies, which largely operate as B2B suppliers, increased their share of fermentation funding from 33 percent in 2023 to 66 percent in 2025. For many of these companies, their products are designed to be incorporated into existing formulations with minimal adjustments, providing specific functional benefits and fitting within established procurement and quality workflows. In a market rewarding commercial clarity, this proved an investable path.

Biomass platforms also remain a critical pathway to high-throughput, lower-cost protein production, particularly where whole-biomass ingredients can deliver neutral flavor and other desirable functional attributes with less downstream processing. As the category matures, the upstream suppliers who execute well can scale in line with tangible buyer demand, improving investors' willingness to finance each stage of growth.

Europe's fermentation ecosystem gains momentum

In 2025, Europe-headquartered fermentation companies ($179 million) raised more than North America-headquartered companies ($154 million) for the first time. Public investment has been a meaningful differentiator in this shift. Across several European markets, governments have supported pilot-to-commercial transitions, fostered innovation ecosystems, and helped catalyze manufacturing capacity. European companies have also drawn on a broad set of financing instruments to extend runway and limit dilution during capital-intensive scale up. Together, these conditions help de-risk scale up and crowd in private capital.

Where a company chooses to build influences timelines, economics, and partnership options just as materially as strain performance or process design. In this environment, Europe is positioning itself as a strategic hub for fermentation—and the broader bioeconomy—by leveraging public and industry investment in infrastructure, production assets, and regulatory and permitting pathways.

Looking ahead

While funding conditions for alternative proteins remain constrained, fermentation companies are well-positioned to embed fermentation-derived ingredients into product portfolios through partnerships and supply agreements. In the near term, the most scalable pathway is likely collaborations that pair technical capabilities with distribution, formulation expertise, and brand credibility. Delivering on these partnerships will require repeatable quality specifications, dependable supply, and compelling unit economics. If they translate into durable commercial traction, they may create clearer exit pathways and increase investor willingness to deploy additional capital into the category.

Until then, financing is likely to remain more selective than in prior years, flowing primarily to companies combining technical execution, well-defined commercialization plans, and disciplined approaches to capital use. For many, the next stage of scale up will require a blended capital stack where private capital is complemented by public and philanthropic support (where appropriate) to de-risk first-of-kind infrastructure and technology. This playbook underpinned growth in sectors from clean energy to global health. Applying it effectively to fermentation can help build capacity for key products and ingredients, increasing optionality and resilience in the food supply.

Photo credit: Perfect Day, Inc.

Consumer insights

Overview

Alternative protein products made from biomass fermentation are broadly available in the U.S. and Europe, but many do not prominently market their use of fermentation. As of 2025, precision fermentation-derived products are available only in Israel and the U.S. and in limited quantities.

This has resulted in low consumer awareness of specific types of fermentation-derived proteins and low familiarity with their benefits in regions where they have been studied, suggesting consumer education should be a top priority for the category.

New studies published in 2025 shed light on current consumer perceptions and provided data on what would lead consumers to choose fermentation-derived proteins. This research can provide insights for messaging, with notable differences across regions.

Asia Pacific consumer findings

Mycoprotein perceptions across Asia Pacific countries

A large study commissioned by FoodNavigator in 2025 covered consumers in 13 countries, seven of them in Asia Pacific (Australia, China, India, Japan, Malaysia, Singapore, and South Korea).

- **Awareness is low:** Similar to research from other regions, it found low consumer awareness of precision fermentation and mycoprotein in Asia Pacific. Awareness was highest in China, Malaysia, and India among covered countries.
- **Interest varies by country:** It also found that interest in consuming mycoprotein was highest in China, Malaysia, and India among countries covered.

Perceptions of human lactoferrin in Australia

One application of precision fermentation is the creation of bioidentical functional ingredients, and several companies are exploring or scaling ways to produce these. This includes human lactoferrin, an ingredient in human breastmilk that has historically been substituted with animal alternatives like bovine lactoferrin in applications like baby formula. A small-scale qualitative study on Australian caregivers explored perceptions of the use of precision fermentation-derived human lactoferrin and found:

- **High acceptance:** Responses to the concept of precision fermentation-derived human lactoferrin were "overwhelmingly positive" after reviewing both a technical infographic about the process of precision fermentation and a high-detail explanation comparing precision fermentation-derived human lactoferrin to bovine lactoferrin in terms of environmental impacts and nutrition. Many expected it would help alleviate the emotional stress that some caregivers experience when feeding.
- **Trust and endorsement will be important for adoption:** Caregivers expressed that they expected several external trust-related factors would drive their decision making: understanding how the product is made with a traditional process like fermentation, wanting the products to be approved by regulators and healthcare providers, and a perceived lack of control when choosing alternatives like traditional bovine-lactoferrin-based baby formulas.

Brazilian consumer findings

An exploratory study by the Federal University of Santa Catarina revealed a relatively high level of conceptual interest in biomass-fermentation-derived products, alongside persistent semantic and knowledge-related barriers.

- **Few are aware of mycelium-based products:** Around one in 10 (14%) respondents were aware of alternative meat products made from edible mushroom mycelium.
- **Many are interested:** A large majority of consumers (82%) expressed interest in trying "mushroom-based meat analogues" when it was stated that they would have added nutritional value and reduced environmental impacts.
- **Likely to appeal to meat-reducers:** Health, environmental, and animal welfare reasons were also their most-cited reasons for interest in reducing meat consumption, which were well aligned with their reasons for interest in mycelium products.
- **Mycoprotein appeals to meat eaters:** The majority of participants identified as omnivores or flexitarians, with just 7% identifying as vegetarian or vegan.

While this was a small-scale study and limited historical research is available in Brazil, it is a positive indication for future demand at a time when numerous Brazilian companies and academic institutions are investing in the development of fermentation-made proteins.

Mycoprotein snack. Photo courtesy of NAPLASOL

European consumer findings

In Europe, several new studies provided data on consumer interest in precision fermentation, building on past research by GFI and Accenture. One study in Germany tested attitudes in the context of a specific product, a Gouda cheese made with precision fermentation. Additional research like this will be necessary to inform future commercial strategies for these products, given their wide range of potential applications.

- **Almost half of European consumers may be open to precision fermentation-derived products:** A study by EIT FOOD on consumers in six European countries (Denmark, France, Greece, Italy, Poland, and Spain) found that almost half (43%) of consumers across these countries would be willing to try dairy products produced using precision fermentation.
- **Research suggests broad openness among UK consumers:** A review by the Food Standards Agency summarizing multiple studies estimated that that more than half of UK consumers (52–68%) would be willing to try precision fermentation-derived dairy or eggs, and that significant minorities would be willing to regularly purchase the products (35%) or add them to their diet (17–31%).
- **Younger and male UK consumers are more open:** A survey by Diffusion on UK consumers found that openness to precision fermentation-derived foods was highest among men (46%, vs. 27% for women), and among younger consumers: more than half of 25–34 year olds (54%) and almost half of 35–44 year olds (48%). Similar demographic patterns have been observed in GFI's research in the U.S., where younger and male consumers tend to express stronger interest in precision fermentation and other alternative protein categories.
- **Few German consumers are familiar, and they are more interested in taste and cost than ethical benefits:** A study by the University of Bonn of German consumers tested openness to "animal-free Gouda" (explained as made with precision fermentation) among those who regularly purchase cheese and are open to conventional Gouda. Fewer than one in 10 (6%) were "familiar" or "very familiar," and two-thirds (66%) had "never heard" of it. In a context of low familiarity, participants were most likely to agree with claims that precision fermentation-derived cheese would promote animal welfare and would be sustainable. They were more divided on whether they thought it would taste good and be safe to eat, which proved more predictive of openness to purchase than ethical benefits were.

U.S. consumer findings

New research by GFI in the U.S. in 2025 saw key consumer metrics for fermentation-derived proteins remaining mostly steady compared to 2024. A minority are aware of precision fermentation-derived or biomass proteins. However, when given a brief explanation, more are willing to try than are aware.

Consumer metrics for precision fermentation-derived (and "animal-free") products

Most are not familiar with precision fermentation: Just one in five have heard of it. This is unsurprising since there are few products on the market in the U.S., and many are labeled as "animal-free" rather than, or more prominently than, "precision fermentation-derived."

Names U.S. consumers have heard for precision fermentation-derived products

Have you ever seen, read, or heard about each of the following?

Poll by Morning Consult on behalf of GFI: n=4,204 U.S. adults, June 2025

*shown to 2,083 respondents

**shown to 2,121 respondents

More are aware of "animal-free," but some may conflate this with plant-based: Past research by GFI and Accenture in the U.S. and Europe showed that many consumers find "animal-free" more appealing than "precision-fermented" and other descriptors for these products. More consumers (almost one in two) report having heard of animal-free products than of precision fermentation-derived ones as of 2025. The gap between awareness of "animal-free" and "precision fermented," and the fact that few precision fermentation-derived products are widely available, suggests that some consumers may conflate precision fermentation-derived products labeled as "animal-free" with other products like plant-based ones.

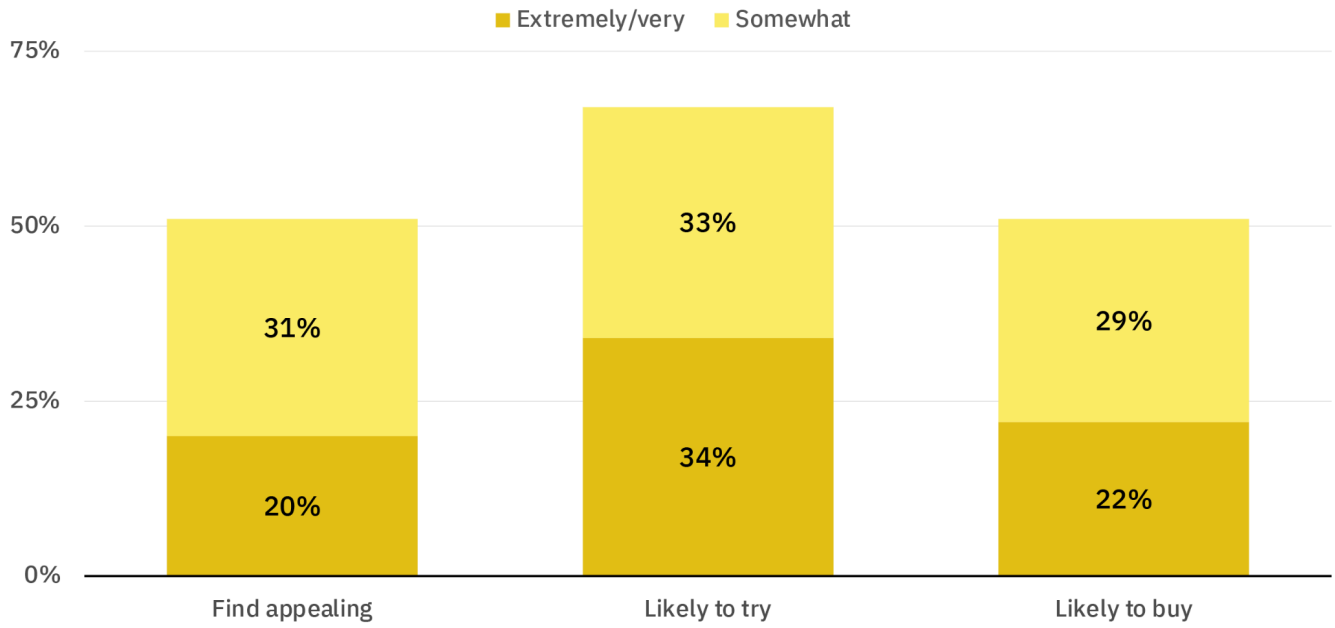
Consumer research is essential for shaping category positioning and nomenclature in the long term. Industry and expert perspectives are also vital early on. GFI APAC and Cellular Agriculture Australia have published a guide to effective messaging for precision fermentation-derived products, developed in collaboration with industry leaders in APAC.

Many are open to precision fermentation-derived products when informed about them: Despite low awareness, consumers are interested in the benefits of precision fermentation-derived products when they're explained. In GFI's 2025 survey, after consumers saw a simple nontechnical explanation of precision fermentation-derived dairy and eggs (how they're made without animals and how their proteins are "identical to what we'd find in milk and eggs"), many consumers expressed interest. This is similar to dynamics seen in other alternative protein categories, where benefits-focused messaging can be effective at normalizing novel ingredients.

- **Many find the concept of precision fermentation-derived products appealing:** More than half (51%) said they found it at least "somewhat" appealing and one in five (20%) "extremely" or "very" appealing.
- **A majority would try them based on a brief description:** Two in three (66%) would be likely to try precision fermentation-derived/animal-free dairy and eggs if given a sample.

U.S. precision fermentation-derived ("animal-free") dairy and egg consumer metrics

2025



Based on the description provided, how appealing or unappealing do you find animal-free dairy or egg products?

If you were offered a free sample of a product made with animal-free dairy or eggs, how likely are you, if at all, to try it?

Based on what you know, how likely are you, if at all, to purchase animal-free dairy or egg products?

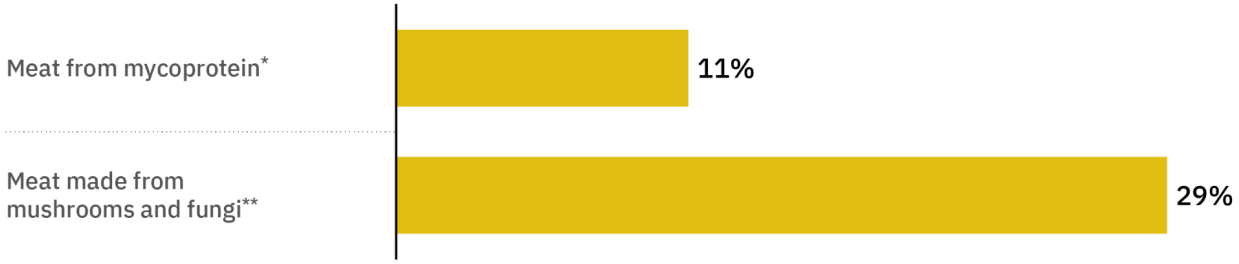
Figures for "Likely to try" sum to 66% without rounding

Poll by Morning Consult on behalf of GFI, n=1,049 U.S. adults, June 2025

Consumer metrics for biomass fermentation-derived products

Awareness is low, both for specific terms and common product concepts: Biomass fermentation-derived products are widely available in the U.S., mostly in the form of meat products made from mycoprotein/mycelium. Brands market these products with a wide variety of terms. This is reflected in low consumer awareness of "mycoprotein," with only one in 10 (11 percent) saying they are aware of "meat made from mycoprotein." Slightly more but still a minority (29 percent) say they are aware of "meat made from mushrooms and fungi."

Names U.S. consumers have heard for mycoprotein products



Have you ever seen, read, or heard about each of the following?

Poll by Morning Consult on behalf of GFI: n=4,204 U.S. adults, June 2025

*shown to 2,083 respondents

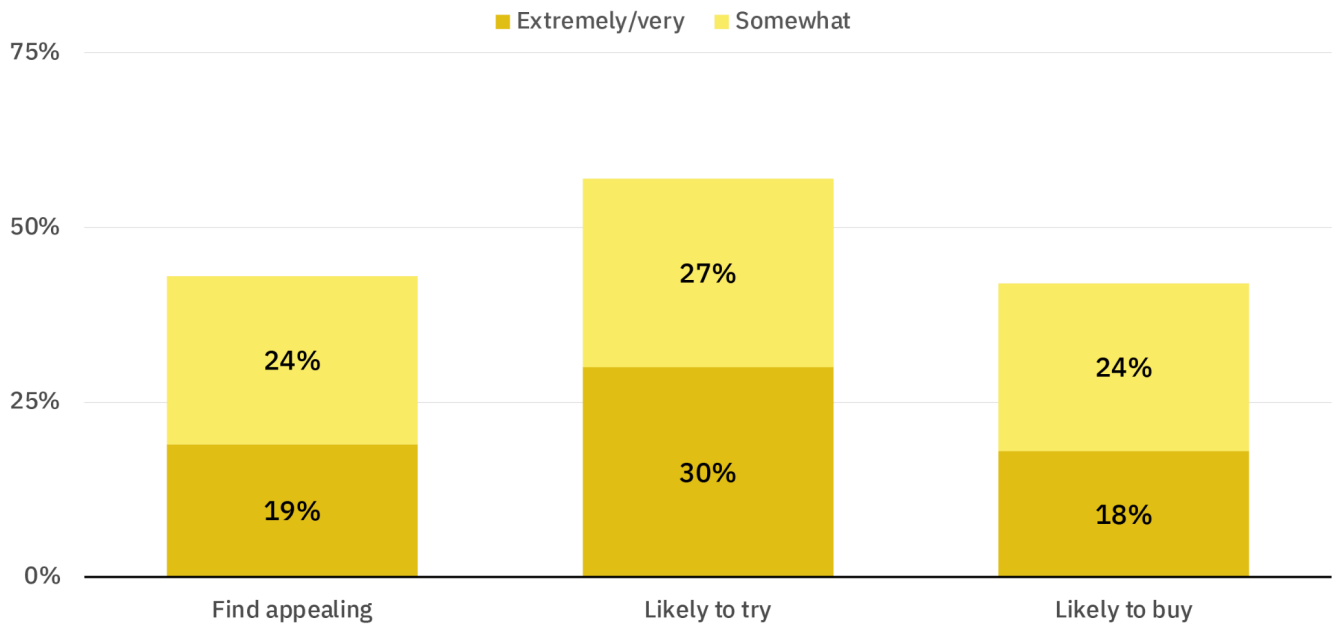
**shown to 2,121 respondents

Rates of awareness did not change significantly from 2024: This is despite the launch of several new biomass fermentation-derived meat products, including from brands like **Beyond Meat**, **Prime Roots**, **Juicy Marbles**, and **Revo Foods**. Some of these products are only available in foodservice or direct-to-consumer, meaning many U.S. shoppers are not interacting with them in grocery stores where packaging and labeling cues are visible.

Openness is higher than awareness: Similar to precision fermentation-derived proteins, more consumers are interested in mycoprotein when it's introduced to them than are aware of it today. Almost half of U.S. consumers find the concept of "meat made from mycoprotein" at least "somewhat" appealing (43 percent), and around one in five find it "extremely" or "very" appealing" (19 percent). More than half would be at least "somewhat" likely to try (57 percent), and almost a third "extremely" or "very" likely (30 percent).

U.S mycoprotein consumer metrics

2025



Based on the description provided, how appealing or unappealing do you find meat products made from mycoprotein?

If you were offered a free sample of a product made from mycoprotein, how likely are you, if at all, to try it?

Based on what you know, how likely are you, if at all, to purchase meat products made from mycoprotein?

Poll by Morning Consult on behalf of GFI: n=1,034 U.S. adults, June 2025

The fact that more consumers are interested in mycoprotein products than are aware of them, despite their current presence in the market, indicates a significant opportunity to increase consumer awareness of the category.

Looking ahead

- **Low awareness is the short-term challenge for consumer products:** Research suggests that consumer familiarity with precision and biomass fermentation-derived proteins is low globally. This includes regions with fermentation-derived meat, dairy, or egg alternatives already available like the U.S. and Europe, ones with extensive traditional use of traditional fermented proteins like Asia, and ones where the concept of fermented proteins is more novel like Brazil.
- **Multiple paths to growth:** Using fermentation-derived ingredients as "drop ins" provides one path to growth that is not highly dependent on consumer awareness as companies scale and reduce costs. But building consumer awareness and educating consumers on the benefits of fermentation-derived products will be necessary to drive adoption of consumer products that make prominent use of these ingredients or wish to market on value-added positionings.
- **Diverse products and use cases create both challenges and opportunities:** The variety of fermentation platforms and product applications makes it difficult to research how consumers will respond to a specific product, especially while so few are available. But it also enables powerful applications for fermented proteins, including in consumer products and as drop-in ingredients for B2B customers. There is a strong need for market research on consumer perceptions of specific product types and value propositions beyond high-level categories like meat, dairy, and eggs.
- **Clear explanation of ingredients and benefits is important:** There will be a strong need for consumer research on specific products and value propositions as more products come to market globally. And companies launching products in this market will need to consider what nomenclature to use, such as "precision fermentation" and "mycoprotein," to create a base of consumer understanding of these products and their benefits.

Science and technology

Overview

In 2025, fermentation researchers optimized diverse microbial strains, developed growth strategies, and fine-tuned ingredient functionality and formulation to create sustainable products. These updates showcase the range of R&D and commercialization efforts across the value chain. Several themes emerged:

1. **Biomass fermentation continues to mature through efficiency gains and end-product characterization.** A flurry of papers showed promising results on improved protein yields, higher productivity, and end-product characterization, signaling efficiency gains and diversification for the decades-old biomass ingredient sector.
2. **Process innovation and feedstock diversification are accelerating.** Across fermentation platforms, companies and researchers demonstrated scaled processes using improved bioprocess designs and alternative feedstocks, reinforcing progress toward efficient and sustainable production.
3. **Ingredient formulation research is building a strong foundation.** Researchers and companies developed innovative formulations and products that match consumer and regional tastes, demonstrating the versatility of fermentation-derived ingredients.
4. **Cost modeling is clarifying the path to price parity.** GFI analyses and other studies provided promising insights on fermentation production costs and key levers. This growing evidence is driving the expansion of the innovation ecosystem and helping facilities produce fermentation-derived proteins and oils at scale.

These themes reflect science and engineering progress observed across fermentation production pillars. Tracking the technological readiness of the fermentation sector is a useful method to evaluate its progress in competing on price, taste, and availability with conventional meat, dairy, and eggs. Technological readiness can be assessed by evaluating progress, challenges, and overall risk across categories such as **scientific feasibility**, **engineering viability**, and **innovation capacity**. In this section, we focus on the most noteworthy dimensions within each of these categories that took center stage in 2025.

Read more about technological readiness levels (TRLs) and commercial readiness frameworks.

Cauldron Demo Facility in Orange, NSW. Photo courtesy of Cauldron Ferm

Scientific feasibility

Strains

GFI's 2025 report on the technoeconomics of fermentation-derived ingredients highlighted that reducing manufacturing costs hinges on improving core bioprocess metrics, such as yield, productivity, and titer (YPT), which are often dictated by strain development. Strain improvements also focus on target food functionality and nutrition. Progress on these R&D strain-improvement priorities was seen in 2025.

- **Advancing mycoprotein strains to improve productivity and quality:** Efforts to improve *Fusarium venenatum,* the longstanding mycoprotein species used in **Quorn** products, accelerated in 2025. A research collaboration between **NIAB** and **Marlow Foods** (Quorn's parent company) has identified the gene responsible for the hyperbranching mutation that accumulates during long-run fermentation batches—an important step toward improved strain stability, productivity, and quality at scale.
- **Targeted mycoprotein strain advances for improved end products:** Researchers at **Seoul National University** and **KIST** found that mutating a sporulation gene increased biomass and amino acid content. Studies from the **Science Center for Future Foods** at **Jiangnan University** have shown that modifications to chitin synthesis can increase protein content and improve digestion, culminating in unprecedented combined improvements in *F. venenatum* nutrition and sustainability. This research links foundational biology to improved mycoprotein productivity, nutrition, and quality.
- **Precision fermentation strain developments enable functionality and bioprocesses:** Several studies reported efforts to improve the functionality of fermentation-derived dairy and egg proteins through post-translational modification. Complementary efforts across academia and industry, including **Denmark Technical University**, **Better Dairy**, **NewMilkBuzz**, and **The EVERY Company**, signal converging strategies using co-expressed kinases or protein design to tune protein functionality. These efforts highlight phosphorylation engineering as a key lever for unlocking functional dairy and egg analogs without fully replicating protein biosynthesis and modification, thus reducing strain engineering and simplifying bioprocess.
- **Microbial host selection reflects target protein needs:** Trends in precision fermentation strain selection continue to align with target protein. Bacterial hosts, such as *B. subtilis* and *E. coli*, are increasingly used for simpler proteins, such as casein. Yeast and filamentous fungi are favored for the production of more complex dairy, egg, and heme proteins. In 2025, *Pichia* strain design continued for heme protein engineering, while *Aspergillus*, a longtime enzyme production workhorse strain, re-emerged as a leading host for protein ingredient production, as seen across company developments including **Verley**, **ImaginDairy**, and **21st.Bio**.

✦ *Key takeaway*

Continued progress in strain engineering is improving biomass and precision fermentation functionality and performance. Further risk and cost reduction requires progress on reported strain-level yields, productivity, and titers to enable commercialization.

Check out GFI Israel's collaboration with Solid Fermentation Innovation: a comprehensive knowledge base on biomass fermentation strains, feedstocks, and cultivation.

Raw materials and feedstocks

Long-term cost competitiveness and sustainability of fermentation-derived ingredients depend on access to cheaper, lower-impact alternatives to first-generation feedstocks like glucose and sucrose. In 2025, progress across sidestream-derived and gas-derived carbon feedstocks signaled a shift toward diversifying inputs for fermentation-derived proteins and oil production, while recognizing the challenges these alternative feedstocks need to address across sourcing, bioprocess performance, and scale up.

- **Next-gen feedstocks for economic and environmental benefits:** GFI's TEA landscape highlighted feedstocks as a primary cost driver. Commercial players like **Standing Ovation** and **NoPalm** are leveraging sidestream valorization to reduce feedstock costs, while environmental analyses continue to showcase carbon-footprint and land-use benefits of alternative feedstocks.

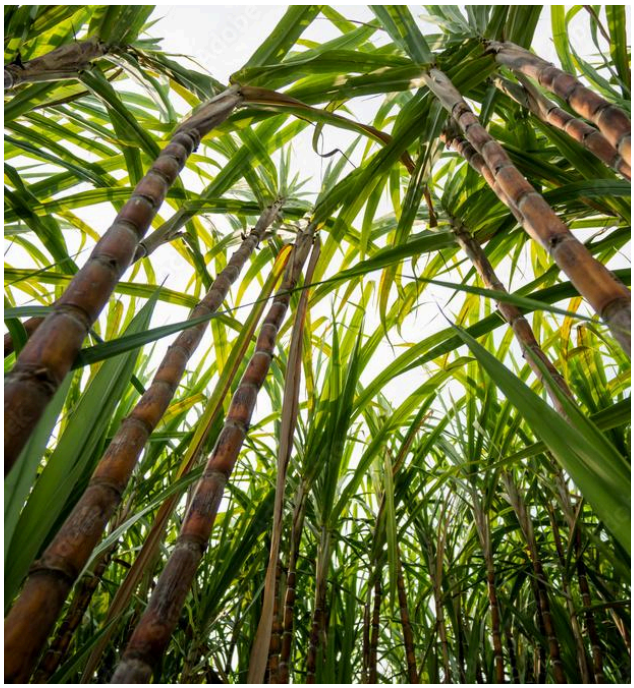


Photo credit: Adobe Stock / Volodymyr_sh

- **Momentum around carbon-capture-based feedstocks accelerated: Novo Nordisk Foundation** has renewed funding for the three-year-old Acetate Consortium, which aims to develop complete acetate-utilizing systems for fermentation-derived food proteins. The **Gates Foundation**, an Acetate Consortium founding partner, has funded **C16 Biosciences** to develop acetate as a feedstock, achieving notable and promising lipid yields on this next-gen feedstock. Complementing these efforts, a **Politecnico di Torino** techno-economic report showed that acetate produced via large-scale carbon capture could be cost-competitive. Exploring other alternative feedstocks like ethanol, **DSM-Firmenich** and **DTU** published an ethanol-fed single-cell protein (SCP) fermentation model that leverages CO_2-to-ethanol conversion, reporting mass transfer advantages and design simplicity compared to direct gas-fed fermentation. Presenting a thorough CO_2-to-SCP pathway, this work lays the foundation for future techno-economic and life cycle analysis (LCA) modeling.

✦ *Key takeaway*

Feedstocks are a primary driver of cost-of-production and a core impact driver in LCAs. Novel feedstocks are achieving higher technical readiness levels and pathways to large-scale production, signaling their potential for large-scale implementation in biomass and precision fermentation ingredient production through economic and environmental modelling.

Check out GFI's fermentation TEM analysis and deep dive for more on feedstocks.

Process advances

While fermentation upstream and downstream processing fundamentals are well established, key commercial risks remain due to low productivity, process instability, or functional losses during purification. In 2025, bioprocess innovation increasingly focused on continuous operation, advanced process control, and sidestream valorization to move fermentation platforms toward higher technology readiness levels (TRLs).

- **Upstream optimization for operational robustness:** Several academic and public–private efforts generated valuable process data on upstream cultivation strategies. These strategies include continuous fermentation yeast pigment production, optimized fed-batch microbial oil production, and high-density SCP production on low-cost substrates, all of which reflect increased focus on productivity and robustness at higher TRLs across fermentation-derived ingredients. High-density SCP cultivation was further supported by a related process patent held by **Sutuo Technology (Beijing) Co.** These studies reflect growing attention to strain–process pairing, productivity over time, and feeding strategy—key requirements for commercial-scale operations.
- **Integrating automation and machine learning into processes:** Multiple companies have advanced machine-learning-based approaches for real-time bioprocess monitoring and control. Patents from **Pow.Bio**, **The EVERY Company**, and **Millow** describe systems that integrate sensor data and predictive models to improve fermentation performance in both submerged and solid-state processes, and even guide product formulation. **Millow** also developed a patented robot-assisted loading system, improving operational efficiency for their oats-fed mycelium solid-state fermentation. Together, these developments suggest that intelligent, efficient control systems are increasingly transitioning from experimental tools to industrial-scale solutions.
- **Downstream processing insights and advances:** Researchers at Wageningen and Utrecht Universities analyzed downstream purification challenges for precision fermentation-derived dairy proteins, demonstrating how unintended glycosylation and cell wall impurities can affect structure–function relationships. **C16 Biosciences** is broadening downstream processing options with the disclosure of a novel enzymatic yeast oil extraction process. This solvent-free alternative, adapted from microalgal oil techniques, could improve costs, safety, and facility access for those not approved for solvent extraction.

✦ *Key takeaway*

Fermentation processes are transitioning from lab- and pilot-scale batch optimization toward higher-TRL manufacturing systems defined by continuous operation, advanced control, and circular resource use. The remaining pathway to commercialization will be shaped by reliable tech transfer of continuous processes, simplified downstream processing, and integration of waste-stream valorization into core process design.

Check out GFI's deep dive on fermentation bioprocesses.

What is blended meat?

Blended meat is defined here as products that combine plant protein or mycoprotein (and sometimes vegetables) with conventional meat components to form an end product. Hybrid meat refers to alternative protein products made from multiple production platforms such as cultivated fat and plant-based proteins. More research and industry alignment are needed around the nomenclature used to describe these emerging product formulations.

End-product attributes

The market success of fermentation-derived and hybrid meat, dairy, and egg products depends on achieving competitive functional, sensory, and nutritional attributes. While these traits are essential for market success, a key risk remains the limited understanding of how technical parameters—such as strains, feedstocks, processing, and formulation—translate into product outcomes.

Encouragingly, 2025 saw substantial growth in formulation and characterization studies for fermentation-derived ingredients in collaboration with private companies.

Biomass ingredient characterization

- **Hybrid and blended mycoprotein formulation:** With **The Better Meat Co.**, researchers at the **University of Massachusetts Amherst** characterized their *N. crassa* Rhiza mycoprotein gelation with plant-based gellan gum formulations, reinforcing the potential of hybrid formulations for optimal texture. They also evaluated mycoprotein in blended meat formulations, demonstrating improved juiciness compared to soy-based controls. Complementing this, **The Better Meat Co.** received patent protection covering *N. crassa* production on potato-based feedstocks and its use in blended formulations, linking feedstock selection with hybrid formulation strategies.
- **Furthering mycoprotein formulation and texturization:** Researchers at **Nanjing Agricultural University** demonstrated that *Rhizopus oligosporus* mycoprotein can achieve improved gelation and fibrous texture when combined with binding proteins and structured using advanced 3D printing. Follow-on work with **Jiangsu Palarich Food Co.** showed that texture can be tuned through fermentation bioprocess and 3D printing, while other studies highlight *Rhizopus*'s favorable ingredient attributes through sensory characterization and end-product formulation.
- **Elucidating texture impacts:** Researchers from the **University of Leeds** and **Quorn** showed that the addition of potato proteins can strongly influence fungal hyphae networks in *F. venenatum*, while **Hefei University of Technology** and **Moon Biotech** reported that adding yeast protein to *Pleurotus eryngii* mycelium-based meat analogs improves texture and mouthfeel.

✦ *Key takeaway*

Mycoprotein end-product development continues to advance, supported by increasing public research, public–private collaborations, and innovation protection around formulations and processing. Further characterization of biomass ingredients at the end-product level—particularly in hybrid formulations and in combination with other SCP sources—is still needed.

Check out GFI Israel's blog post and GFI APAC's report on blended meat formulations.

GFI's Research Grant Program (RGP) is a global research engine that has awarded over $24 million to 129 projects across 25 countries. The RGP is only possible through the generous support of GFI donors.

The RGP welcomes five new 2025 grantees focused on improving plant-based meat formulations using fermentation-derived ingredients. Read about GFI's newest grantees here.

Breakfast empanadas. Photo courtesy of Motif FoodWorks

Precision fermentation ingredient characterization

Developing cheese-like functionality: Developments in 2025 demonstrated that precision casein formulations can achieve cheese-like melt and stretch with or without strict replication of native casein and micellar curd assembly.

- **Casein micelle characterization and commercialization:** To replicate ingredient functionality, understanding how micelles form and then how they function is important. Researchers at **All G Foods** and **Penn State University** established native bovine casein micelle size benchmarks, while **Wageningen University** showed that artificial micelle structure and curd strength depend on casein composition. Signaling commercial formulation progress, **Formo** developed a continuous formulation process for artificial casein micelle production.
- **Casein structure-function advances:** Researchers at **Fermify and BOKU University** showed that non-phosphorylated precision β-casein forms stronger acid-induced gels than native casein, opening applications for precision β-casein as an ingredient in ready-to-drink beverages and yogurt products. Elsewhere, by relying on a patent-pending enzymatic process rather than full replication of casein micelles, **Fermify** has demonstrated authentic cheese formulations with non-phosphorylated β-casein produced from bacteria, reducing strain engineering efforts and improving extraction. Complementary work from **Aarhus University** demonstrated improved digestion using non-phosphorylated casein.

Whey and heme proteins for functionality and flavor: Precision fermentation enables functional tuning beyond native whey protein, while heme proteins continue to demonstrate strong sensory benefits in plant-based meats.

- **Tuning whey protein functionality:** Collaboration between **Vivici**, **Fonterra**, and **Massey University** demonstrated that engineered beta-lactoglobulin can improve gelation and emulsification through protein and process design. In parallel, **Verley** also reported patent-pending functionalized beta-lactoglobulin, enabling dairy formulations with fewer ingredients.
- **Characterizing high-value lactoferrin:** Separate studies from **Turtletree Labs** and **RMIT University** with **All G Foods** showed that precision fermentation-derived lactoferrin closely matches native protein structure while preserving bioactive functionality and stability.
- **Heme protein enhances plant-based meat:** Academic studies from **Zhejiang University** and **Jiangnan University** continued to show that leghemoglobin and myoglobin ingredients enhance aroma, color, and texture in high-moisture extrusion meat formulations, aligning with **Impossible**'s higher concentration formulations, **Paleo**'s protected myoglobin formulation, and myoglobin's food colorant listing.

✦ *Key takeaway*

Precision fermentation is moving toward scalable functional equivalence in plant-based meat and dairy formulations, delivered by protein design, processing, and formulation advancements. The remaining pathway to commercialization will be defined by end-product validation, formulation optimization, and integration into food systems in partnership with CPG leaders.

Engineering viability

Quality control and food safety evaluations

Food safety and quality control for fermentation-derived ingredients continue to benefit from well-established industrial fermentation practices, with 2025 reinforcing that most risks are known, manageable, and already addressed by many existing regulatory and manufacturing frameworks globally.

As highlighted in the 2025 **FAO** report on precision fermentation, the majority of food safety hazards associated with fermentation—microbiological, chemical, and process-related—are not novel and are mitigated through standard tools such as good manufacturing practices, hazard analysis, hygienic equipment design, and safety assessment frameworks.

- **Regulators continue to refine safety assessment guidelines:** Recent **European Food Safety Authority (EFSA)** updates include new guidance on microorganism characterization and suggested frameworks for assessing newly expressed proteins. This guidance emphasizes a weight-of-evidence approach, combining bioinformatics, digestibility studies, and targeted toxicology, which moves away from defaulting to animal testing for safety and regulatory testing.

- **Safety evaluations advanced:** Multiple peer-reviewed food safety hazard and toxicity studies were published across biomass and precision fermentation, including evaluations of novel *Fusarium compactum* mycoprotein by **MoreMeat Biotech Co.**, an engineered yeast SCP expressing lamb protein by **Bond Pet Food**, a methanol-fed SCP postbiotic by **X-Food Shanghai Biotechnology**, and a safety panel for precision lactoferrin by **Helaina**. These studies, along with positive EFSA scientific opinions for **Protein Brewery**'s *Rhizomucor pusillus* mycoprotein and **Superbrewed Food**'s bacterial SCP postbiotic, demonstrate growing precedent for ingredient-specific safety validation across geographies, processes, and strains.
- **Managing allergenicity and process-related risks:** As precision fermentation increasingly targets proteins analogous to known allergens (e.g., milk and egg proteins), allergenicity and unintended immune responses remain areas of scrutiny. Recent clinical data on precision fermentation-derived lactoferrin and expanded digestibility and toxicity testing across novel proteins reflect progress toward de-risking these concerns. At the same time, legal and labeling challenges underscore the importance of protein purity, transparent communication, and consistent quality control, particularly as processes scale and diversify.

✦ *Key takeaway*

Quality control and food safety for fermentation-derived ingredients remain relatively low-risk, supported by decades of industrial fermentation experience, mature regulatory pathways, and a growing body of ingredient-specific safety data. Continued risk reduction will depend on transparent safety testing for new strains and proteins, rigorous control of fungal and allergenic risks, and alignment with evolving regulatory guidance as fermentation platforms expand in scale and scope.

Check out GFI Europe's blog post covering the FAO's food safety in precision fermentation report.

Scaling and process validation hit crucial milestones

Scaling and process engineering viability reflects whether fermentation processes can be scaled, transferred, and operated reliably across volumes, feedstocks, and production environments. In 2025, multiple companies advanced validation at demo and commercial scales, strengthening confidence in fermentation's scalability while also surfacing persistent operational and economic constraints.

- **Continuous fermentation systems mature:** A major signal this year came from **Pow.Bio**, in collaboration with **Bühler,** by demonstrating scalable, transferable continuous fermentation of high-value dairy proteins at 3,000-liter scale with **ATV Technologies.** The scale up achieved over threefold productivity gains and a 50% reduction in costs, enabled by Pow.Bio's patent-pending continuous process technology and machine learning-based bioprocess control platform. **Cassius AB** further reinforced momentum toward continuous precision fermentation by developing a multibioreactor continuous process for bacterial growth and casein production.
- **Mycoprotein scaling developments:** A new commercial mycoprotein producer, **Planetary Group**, scaled up with a 50,000-liter industrial-scale manufacturing site in Aarberg and secured a patent for mycoprotein dairy formulations using *F. venenatum.* Elsewhere, **Jiangnan University** validated production of an engineered *Fusarium* strain at 5,000-liter scale.
- **Microbial oil scaling advances:** Microbial palm oil producer, **C16 Biosciences**, reported scale up of an oleaginous yeast strain to 50,000 liters, supported by adaptive laboratory evolution and high-cell-density fed-batch operation. **ÄIO** completed their first full-scale production validation, producing one tonne of yeast-based encapsulated oil—a 300-fold increase over lab output.

- **De-risking alternative and sidestream-derived feedstocks:** Several companies validated circular feedstock strategies under commercially relevant conditions, marking important food biomanufacturing scaling milestones on abundant sidestreams. **NoPalm Ingredients** validated production of their patented microbial palm oil alternative at 120,000 liters using food-waste-derived feedstocks. **Standing Ovation**, in partnership with **Bel Group**, demonstrated production of precision casein using acid whey, a major dairy sidestream, as a feedstock.

Site selection is an important scaling risk factor

GFI APAC and **Hawkwood Biotech** published *Where to build,* an evaluation of fermentation manufacturing competitiveness across nine APAC countries based on feedstock access, operating costs, and regulatory readiness. Thailand, Australia, and Vietnam emerged as particularly strong locations for food biomanufacturing. In contrast, **Meati**'s bankruptcy in 2025—despite commercial production—highlighted how labor, electricity, water costs, and local tax environments can materially affect commercial viability.

✦ *Key takeaway*

Fermentation processes have been validated at demo and commercial scales across proteins and oils, indicating strong engineering feasibility. However, scaling remains a risk, with success increasingly determined by sustained operation, feedstock flexibility, downstream integration, and site-specific economics. Continued scale-up risk reduction will depend on longer-duration validation runs, broader operating contexts, and transparent process performance data to bridge the gap from technical scale to durable commercial deployment.
Check out GFI Europe's scale up series blog.

Economic and environmental costs become clearer

Cost remains a central driver of whether fermentation-derived ingredients can scale and compete with conventional food ingredients. In 2025, expanded use of techno-economic assessments (TEA) and life cycle assessments (LCA) sharpened visibility into cost competitiveness, key cost drivers, and areas of need across fermentation platforms.

- **Benchmarking production costs:** In collaboration with **Hawkwood Biotech**, **GFI** released *Driving Down Costs*, a comprehensive analysis of fermentation-derived ingredient TEAs that benchmarked production costs and highlighted capital efficiency, feedstocks, raw materials, and productivity as core cost drivers for ingredients.
- **Biomass proteins approach cost parity:** Reinforcing findings in **GFI**'s landscape, new TEAs in 2025 for gas fermentation SCP from **LUT University** and **Solar Foods**, the **Weizmann Institute**, and **DTU**, along with a molasses-fed SCP model from **Taiyuan University of Technology**, demonstrate biomass production costs competitive with conventional animal proteins and some commodity plant proteins.
- **Precision fermentation models reduce uncertainty:** New precision fermentation TEA models filled data gaps and helped identify early-market targets. **GFI Europe** and **Arthur D. Little Consultancy** published a powerful framework to identify promising precision fermentation ingredients based on production cost and market fit, while **Intelligen**'s egg-white protein TEA reaffirmed capital costs, raw materials, and process efficiency as dominant cost drivers. Models also highlighted waste-biomass valorization as a production cost lever.

- **Environmental assessments reinforce sustainability:** New mycoprotein LCAs for *Y. lipolytica* and *F. venenatum* production showed sustainability advantages over conventional meat, while identifying process areas for improvement. Precision dairy and egg protein assessments highlighted land-use and carbon-footprint benefits when paired with renewable energy and sidestream feedstocks.
- **Toward standardized TEA and LCA practices:** While LCAs are already ISO standardized, recent publications—including **GFI**'s TEA landscape, a new LCA best practices review, a **CSIRO** TEA commentary, and the new **ISO** environmental techno-economic assessment (eTEA) technical specification—underscored the need for consistent model assumptions, reporting, and transparency to enable meaningful comparison and credibility.

✦ *Key takeaway*

Economic and environmental cost evidence increasingly supports biomass fermentation benefits, while precision fermentation is earlier in its cost de-risking path. Advancing toward commodity markets at lower risk will require validated paths to lower production costs, transparent and standardized TEA, and continued advances in strain performance, feedstock cost, and process design. Environmental impact analysis can help guide site selection, drive resource-light bioprocesses and equipment, and engage stakeholders through emissions reduction mandates.

Have a new fermentation TEA publication? Submit it here.

Global innovation capacity

A robust public and private R&D ecosystem is vital for industry growth. This global innovation capacity is tracked across **regional bioeconomy growth**, **intellectual property (IP) infringement**, and **patent innovation activity.** In 2025, the global bioeconomy, knowledge base, and innovation landscape continued to expand.

Regional bioeconomies gain healthy momentum

Newly launched and expanding research centers and facilities are strengthening translational, scalable innovation. Publicly funded infrastructure plays a key role in de-risking process development and scale up for fermentation-derived products. These innovation centers underpin how funding can build regional bioeconomies through strategic end-to-end infrastructure solutions for companies at all stages of development.

- **Brazil:** Brazil is strengthening its biotechnology and synthetic biology ecosystem through coordinated research networks such as the **UFSC Biotech Network (Rede Biotech)** and the **Brazilian Synthetic Biology Network**, which focus on bioprocess engineering, microbial platforms, and precision biotechnology. Recent analyses on biofoundries in Latin America highlight the importance of these coordinated networks, combined with advanced open-access infrastructure. These efforts are supported by public funding, including $2.5 million to establish the **National Institute for Biofactories** (INCT–Biofábricas).
- **Canada:** In Nova Scotia, the **Verschuren Centre** received provincial funding for expansion, as did the **Neptune Bioinnovation Centre**, which will commercialize precision fermentation products, including food proteins.
- **India:** Under India's national **BioE3 policy**, a network of 21 bio-enabler infrastructure projects, consisting of biofoundries and biomanufacturing hubs, was established under a public–private partnership model to address the gap in accessible infrastructure for scale-up validation and pre-commercial production of bio-based innovations. Under this initiative, a biofoundry dedicated to fermentation-derived "smart proteins" has been established at the **National Agri-Food and Bio-manufacturing Institute**. Additionally, at least three biomanufacturing hubs, financed through the bioenabler scheme and run by **Laurus Bio**, **HiMedia Laboratories**, and **Sundyota Numandis**, are being set up as industry-led biomass and precision fermentation facilities for alternative proteins and ingredients.
- **United States:** Public–private infrastructure development continued across many regions. The Illinois **iFAB tech hub** advanced its precision fermentation consortium, helping Illinois increase its impact on the alternative protein ecosystem as it builds out coordinated infrastructure. In California, **BEAM Circular** rolled out an accelerator program focusing on sidestream utilization, which includes two fermentation-derived food companies, **Oleo** and **Optimized Foods**, and acquired gas-fermentation pilot assets for their innovation campus. Meanwhile, **BioMADE,** a Manufacturing USA Institute, has announced a network of three new fermentation facilities for biomanufacturing, in California (pilot), Minnesota (demonstration scale), and Iowa (pilot scale). These facilities are significant infrastructure investments that enable multiple users to fully utilize the equipment and expertise they house.

✦ *Key takeaway*

These facilities, programs, infrastructure, and the public funding that support them are critical for scale up, de-risking, and innovation that paves the way for private investment and fermentation-derived product commercialization.

Are you a member of an alternative protein startup, producer, research body, or other organization in the ecosystem? Check out the GFI alt protein ecosystem map here and add your information!

IP infringement is a risk to commercialization

Relying on novel ingredient innovations, fermentation-derived proteins and oils are entering food and ingredient markets. However, as the industry scales toward global commodity supply, multiple companies will pursue similar ingredients using different microbial hosts, processes, and formulations. This scenario creates an inherent tension between protecting innovation through intellectual property rights and maintaining sufficient freedom to operate for industry-wide growth.

- **IP disputes signal commercialization risk:** Recent years have seen multiple high-profile disputes in fermentation-derived products, including cases involving **Onego Bio** and **VTT** v. **The EVERY Company** for precision egg-protein strains, **DSM-Firmenich** v. **Mara Renewables** regarding algal oil compositions, **The Better Meat Co.** v. **Meati** for mycoprotein processes, **Fonterra Co-operative Group** v. **Perfect Day** for dairy proteins, and **Impossible Foods** v. **Motif Foodworks** for heme proteins. Often, prolonged legal proceedings coincided with major business disruption or even company closures. While company exits occur in competitive markets, protracted IP conflicts around foundational technologies risk slowing sector-wide scaling.
- **IP protection and licensing can also enable scale and investment:** Patents and licensing remain essential tools for investment, partnerships, and commercialization, enabling companies like **Perfect Day**, **Impossible Foods**, and **DSM-Fermenich** to de-risk financing and bring ingredients to market. Elsewhere in industrial biotechnology, companies have successfully used joint ventures to commercialize bioproducts, such as **Calysta** and **Adisseo** with SCP feed and **GENO** with Bio-BDO and nylon, by delineating IP ownership and protecting their technologies through licensing and manufacturing agreements. In food applications, **Dyadic** and **BRIG BIO**'s development agreement for precision fermentation-derived alpha-lactalbumin is an early step toward accessing established microbial hosts through licensing—tackling technical barriers and reducing development timelines.

✦ *Key takeaway*

Intellectual property represents a commercialization risk, not a purely technical one, that will increasingly shape which fermentation ingredients and platforms scale successfully. Reducing this risk will require clearer IP claim boundaries and greater use of licensing and joint ventures. Balancing innovation protection with freedom to operate will be critical for sustaining competition, investment, and long-term industry growth at a global scale.

The role of public investment in accelerating fermentation

Private investment has driven much of the early innovation in fermentation-derived ingredients, significantly outpacing public R&D funding in recent years.

As a result, key advances in production strains, bioprocesses, and formulations are often developed under proprietary models. While this supports commercialization, it can limit shared learning and access to foundational tools across the field.

Greater public investment in open-access research can reduce duplication, lower technical barriers, and accelerate progress toward a more sustainable and diversified protein system. Public–private consortia such as the **Gates Foundation**- and **Novo Nordisk Foundation**-backed Acetate Consortium, regional bioeconomy hubs like **iFAB** and **BEAM**, and philanthropically supported centers, including the **Bezos Centers for Sustainable Protein**, demonstrate how pre-competitive funding and infrastructure strengthen the ecosystem.

While encouraging, these developments barely scratch the surface of the public funding goals for protein diversification recommended by the **ClimateWorks Foundation**. Sustained public investment in open-access R&D, precompetitive cooperation, and private-sector partnerships will be essential to a commercially thriving fermentation sector.

See the latest global public funding developments in the Government and regulation section below, and GFI Europe's research and innovation funding landscape report.

Patent innovations continue to grow

Patents, a cornerstone of innovation protection, are one metric for analyzing innovation within the industry. More than 2,900 unique patents for fermentation-derived alternative proteins have been filed over the past 15 years, demonstrating significant ecosystem growth and scientific progress. Last year's analysis suggested that patent activity was slowing globally—this was partially wrong. Updated figures show the number of unique innovations (patent families) and assignees reached all-time highs in 2023. This trend signals scientific growth from a broader, more diverse inventor base and 2024 data suggests this trend will continue. This expansion is likely driven by past funding, as patent filings are generally a lagging indicator of investment and a leading indicator of commercial innovation.

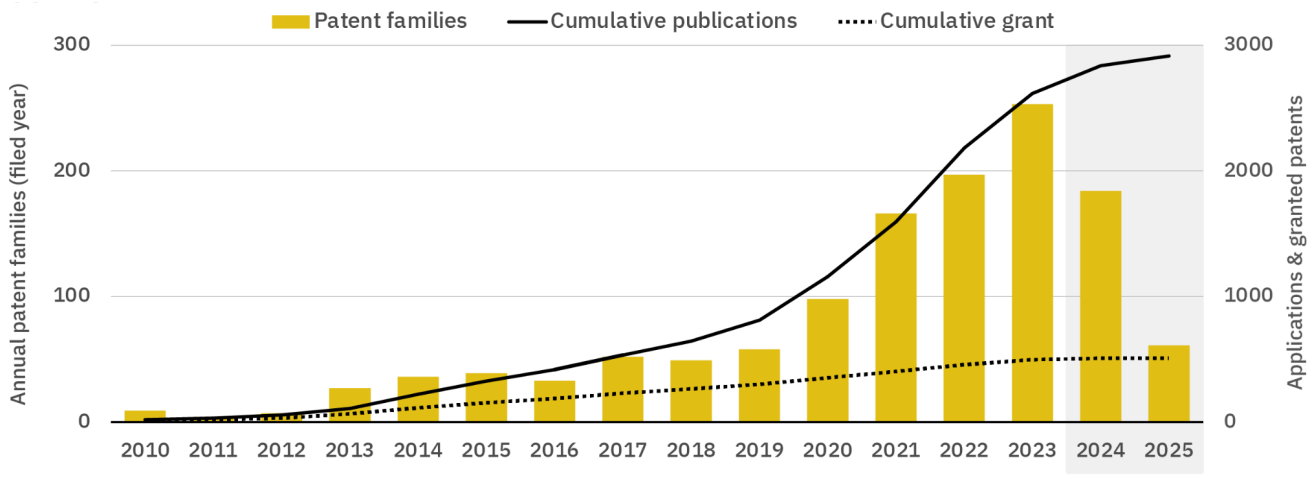
However, the global patent landscape for fermentation innovations is shifting, with total filings decreasing since the 2022 peak despite increases in patent families in 2023 and 2024. This suggests a move toward prioritizing strategic protection over broad global applications, likely driven by regional commercialization strategies and reduced funding.

For the tracked companies and filings, the United States and Europe remain the dominant patent jurisdictions, reflecting key consumer markets, innovation ecosystems, and manufacturing hubs. They are followed by Australia, Israel, South Korea, China, and Canada. For inventor locations, the United States leads, followed by China, Germany, Israel, the Netherlands, and the United Kingdom—indicating a growing ecosystem for both innovation and patent protection in those countries.

Access GFI's fermentation patent landscape dataset and analysis dashboard. Additional information on European patents can be found at GFI Europe's patent analysis, which revealed that patent publications by European alternative protein innovators have increased by 960 percent over the last decade.

Annual patent family findings and cumulative patent activity

By filed year



	2020	2021	2022	2023	2024	2025
Jurisdictions	32	25	28	26	19	12
Assignees	40	70	98	117	104	46
Global patent filings	345	436	587	434	224	75

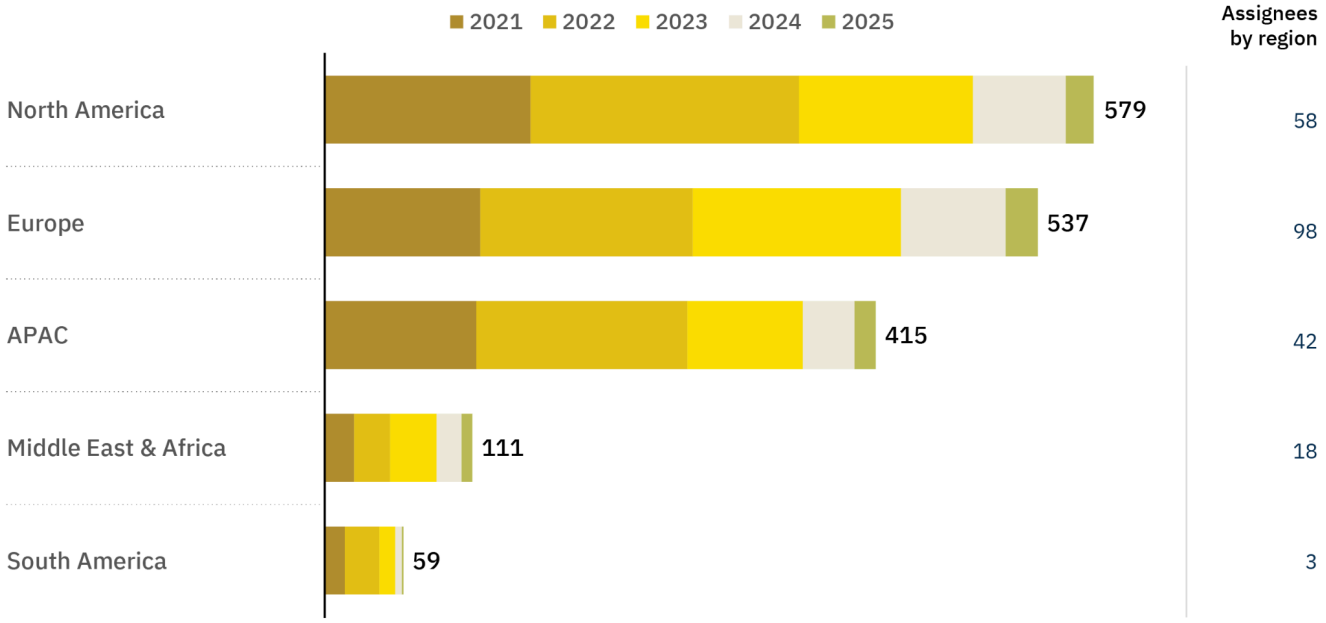
Annual patent family and cumulative patent filings from 2015 to 2025 by filed year. Cumulative applications represent total unique patent filings across jurisdictions, while patent families represent unique innovations. Gray area represents incomplete datasets for those years.

A note on data: 2024 and 2025 filing numbers are incomplete and do not accurately inform activity in those years as patent publication can be delayed up to 18 months after filing.

Source: Data sourced from Dimensions, an interlinked research information system provided by Digital Science (www.dimensions.ai).

Global fermentation patent filing regions

By filed year and application origination jurisdiction



Global fermentation patent filings by region between 2021–2025 based on applications filed in regional intellectual patent offices (IPOs) (left) with the number of aggregated assignees by location (right). Regional IPOs are in order of jurisdiction patent counts: North America: US, CA, MX, DO; Europe: EP, GB, FI, SE, FR, DE, AT, ES, NL, PL, DK, BE; APAC: AU, CN, KR, JP, PH, IN, SG, NZ, RU; Middle East & Africa: IL, ZA, CY; South America: BR, CL, CO, AR, PE, EC.

Source: Data sourced from Dimensions, an interlinked research information system provided by Digital Science (www.dimensions.ai). A note on data: 2024 and 2025 filing numbers are incomplete and do not accurately inform complete activity as patent publication can be delayed up to 18 months after filing.

Patent search method:

Fermentation patent searches specific to alternative proteins are difficult to query by tailored keywords due to the broad applications of fermentation. Expanding on our 2024 patent landscape, this landscape used company-based and keyword-based patent queries, both tailored for fermentation-derived alternative proteins. The methodology used curated company assignee legal filing names and patent title, abstract, and claims (TAC) keyword searches with TAC exclusions. Duplicate patents (by family ID and jurisdiction) were removed, and remaining patents were manually screened for fermentation-derived alternative protein relevance. Assignee legal filing names were manually translated and curated by the most relevant company name and inventor location.

Access GFI's fermentation patent landscape dataset. More company details are available in the GFI company database. Are we missing something? Please let us know by filling out our company database edits form or contact us at corporate@gfi.org.

Government and regulation

Global public investment

Nearly every major government or bloc tracked by GFI maintained or increased support for fermentation-related research and commercialization efforts in 2025. Many of these governments implemented wide-ranging biotechnology plans, recognizing the potential benefits to the economy, food system, and national security, and often included precision fermentation or other microbial protein sources as key planks. Because fermentation technology has many scientific, economic, and equipment overlaps with other bioproducts of interest, and because developing food-grade production capacity unlocks a greater variety of these products, developing fermentation capacity for food ingredients is consistently included as a necessary component of building the bioeconomy.

Governments in 2025 made large commitments toward developing strategic manufacturing capacity and the domestic demand to maintain it:

- China began to mobilize large-scale investment in support of national and regional biomanufacturing development through the State Development & Investment Corporation (SDIC), with some of this investment certainly increasing food-grade precision and biomass fermentation production capacity.
- The European Union and the United Kingdom each announced supportive policies for infrastructure development, commercial readiness, and scientific leadership backed by large investment commitments.
- India began to enact the BioE3 policy to support ambitious, catalytic investments, including building new fermentation capacity.
- Australia, California, Canada, and South Korea made large public investments in building new infrastructure for shared commercial use, working across both food and non-food applications.

Public investment in 2025 took a variety of forms. Governments in Australia, Canada, India, South Korea, the U.S. state of California (the fourth-largest economy in the world), and more announced or completed publicly supported biofoundries and biomanufacturing centers, which seek to address bottlenecks in the R&D and commercialization processes. The European Union awarded a seven-figure loan to a fermentation company to build a commercial facility and a new blended-finance grant and loan to another, while China's SDIC and South Korea's Jeonbuk Innovation Success Venture Fund will invest directly in companies. Governments from Brazil to New Zealand funded public research on fermentation techniques, and the majority of the governments who funded new research in 2025 did so with the intention of creating new markets for local resources or sidestreams, positioning their agricultural producers for success in a more sustainable, circular food system.

Across the board, public investment in fermentation was seen as a strategic investment in food security and sovereignty, a boon to both the biotechnology and agricultural sectors, and a driver of growth in jobs, scientific leadership, and healthy, sustainable foods.

Americas

Brazil

The state government of Paraná continued to lead Brazil's investments in research and commercial support for fermentation and other new food technologies, with new public research efforts announced at the state level in 2025. The Araucária Foundation, a research organization funded by the state of Paraná, announced the winners of an alternative protein research call jointly funded by GFI Brazil; two of the four winning projects will advance biomass fermentation. This follows a 2024 grant from the state government of Paraná to **Typcal**, a biomass fermentation company pioneering the use of Brazilian fungi in mycoprotein products.

Paraná was joined in 2025 by the neighboring state of São Paulo, which began three new research projects on fermentation from methane and algae, as well as for precision fermentation of dairy, at local universities through the São Paulo State Research Support Foundation.

Canada

While the majority of Canada's support for new protein sources goes toward the country's strong plant-protein sector, governments at the federal and provincial levels took action in 2025 to boost fermentation capacity so that Canadian startups need not look abroad as they scale up.

In January 2025, the province of Nova Scotia announced a CAD 1 million ($730,000) grant to fund expansions at the Verschuren Centre, a pilot-scale (10,000L) precision fermentation facility constructed with federal and state economic development funding in 2022. Although initially focusing on petroleum-based products, the center is also conducting research on precision fermentation-derived food products and expects to serve 50 clients simultaneously, including food producers.

Shortly after, the Government of Canada's Atlantic Canada Opportunities Agency announced CAD 5 million ($3.5 million) in funding to construct the Neptune BioInnovation Centre in nearby Dartmouth, Nova Scotia. "Canada's first large-scale bioinnovation centre," the facility will serve as a demonstration-scale contract manufacturer for local startups, offering up to 100,000 liters of precision fermentation capacity.

In 2025, Prairies Economic Development Canada awarded CAD 1 million ($700,000) to the Cellular Agriculture Prairies Ecosystem (CAPE) Project, an initiative by New Harvest Canada to ensure that Canada's breadbasket shares in the benefits of new food production systems. CAPE will support research that identifies how Canadian crops can be used in cell cultivation and fermentation as feedstocks and conduct life cycle assessments to determine the environmental and economic impacts of a diversified food system. Similarly, Protein Industries Canada, a federally funded innovation cluster mostly advancing the plant protein sector in Canada, provided CAD 6.3 million ($4.5 million) in funding to a project to scale up fava bean processing, with one of the project partners being a biomass fermentation company using these Canadian-grown inputs to develop mycoprotein.

These projects underscore the synergies between the plant-protein and fermentation-derived food sectors, as well as the many potential benefits for farmers and rural communities.

United States

The United States drastically scaled back all federally funded R&D in 2025, cutting the number of new grants awarded by the National Science Foundation (NSF) by 25 percent in 2025 and leading to an estimated 25,000 scientific research jobs lost from federal agencies and 20,000 scientific research jobs lost in the private sector. The United States is also expected to lose its position as the world's largest R&D funder to China in 2026. As a result, after consistently rising from 2021 to 2024, federal investments in fermentation and enabling technologies in the United States declined from a peak of $108 million announced in 2024 to an estimated $1.3 million announced in 2025. In doing so, the United States bucks the global trend of investing competitively in biotechnology and biomanufacturing, of which fermentation for food is an essential component.

Though fewer and smaller new research projects or commercialization support efforts were announced in 2025, ongoing projects from years past continue to advance the science and scaling of biomass and precision fermentation. In addition, new Small Business Innovation Research grants from NSF allowed startups to investigate new methods and ingredients, fueling entrepreneurship.

NSF also supported collaborative research applying AI to precision fermentation with the BioMADE Manufacturing Innovation Institute, the University of California, Berkeley, and an International Research Experiences for Students program to place U.S. engineering students in alternative protein labs in New Zealand through the University of Tennessee, Knoxville. The United States Department of Agriculture (USDA) also supported an initiative to train food science students on alternative protein methods at San Diego State University and a food safety initiative for evaluating fermentation-derived products at Tufts University.

Beyond the federal government, the state of California announced three initiatives in 2025 that will advance fermentation as part of a suite of new food technologies, underscoring the state's pursuit of leadership in food production, processing, and innovation. The California Jobs First Regional Investment Initiative, an innovation engine focused on developing new industries in key development regions, awarded over $10 million to BEAM Circular to build the California Bioeconomy Innovation Campus, a bioproduction facility that will allow researchers and startups to test products from pilot-scale to demonstration-scale.

California Jobs First also committed nearly $1 million to the University of California Agriculture and Natural Resources to build a Plant Food and Agricultural Innovation Center, a research facility that will include equipment for developing cultivated meat and fermentation-derived foods. Further shoring up the state's research leadership, the California legislature earmarked $1 million for the University of California, Davis's Integrative Center for Alternative Meat and Protein, a hub for fermentation research.

California was not alone in making commitments to developing fermentation technology. Illinois's Alternative Protein Innovation Task Force, a team convened in 2024 to study the landscape of alternative proteins in Illinois and to develop policy recommendations, released its final report in December 2025, calling for the state to support biomanufacturing for alternative proteins through funding programs, research leadership, workforce development initiatives, public procurement, and clear regulation.

Albany County, New York, became the first known U.S. county to support alternative protein scale up and market access with a $1.6 million combined grant and loan to **Ecovative** to support research and production of their mycelium-based bacon and other sustainable goods.

Asia Pacific

Australia

The government of Australia unveiled several initiatives in 2025 to support the developing precision fermentation sector, including a newly opened Pioneer BioPilot biomanufacturing hub in Queensland, which has been backed by AUD 18 million ($11.8 million) in public investment from the federal and state governments. The public–private partnership will allow startups and entrepreneurs to test new methods and technologies alongside Queensland University of Technology researchers.

Eclipse Ingredients, a lactoferrin precision fermentation company, emerged from stealth mode in 2025 with AUD 2.9 million ($1.9 million) in investment from Australia's Food and Beverage Accelerator, a public–private partnership funded by the federal government's Trailblazers University Program. The company then received an additional AUD 1.9 million ($1.2 million) from Australia's Industry Growth Program, an initiative to build manufacturing capacity through commercialization grants to startups.

Invest Victoria updated their "Alternative Proteins" investment positioning page to explicitly name alternative proteins, including fermentation, as a priority area, pointing to state and federal programmes and finance mechanisms to encourage commercialization.

China

In keeping with trends from past years, China's investments in fermentation-derived foods and other "new proteins" grew both larger and more explicit in 2025, with a variety of actors at the national, state, and municipal levels announcing new investments in biotechnology research, industry development, and infrastructure.

In May 2025, the state-owned State Development & Investment Corporation (SDIC) announced a commitment of over CNY 4 billion ($555 million) toward advancing biomanufacturing infrastructure development through investments in domestic biotechnology companies. Though not all of these biomanufacturing operations will be food-grade or otherwise pertinent to fermentation-derived foods, "new proteins" do figure prominently: the SDIC simultaneously announced a Novel Protein Bio-Manufacturing Innovation Center to be established at Jiangnan University with co-funding from the city of Wuxi. The center will directly address bottlenecks in scaling the industrial production of new protein products, including through fermentation, accelerating the commercial path to market.

SDIC has also established regional biomanufacturing funds "to provide financial ammunition for the biomanufacturing industry," offering much-needed capital for startups to build facilities and create regional supply chains. Such funds, endowed with about CNY 1–2 billion ($145–290 million) each, have been established in the Tianjin Haihe region, Anhui province, and the city of Hangzhou. These are similarly broader in scope than food production alone, but nevertheless represent an unmatched effort to achieve biomanufacturing leadership on the global stage.

Also in keeping with past years' trends, China's largest municipalities advanced development agendas that featured fermentation and other new food technologies among broader "future industries" to receive government support. Following 2024 efforts from the cities of Beijing and Nanjing to scale new protein production, including through a CNY 80 million ($11 million) alternative protein innovation center in Beijing's Fengtai district that opened in 2025, the city of Shanghai announced a Shanghai Future Industry Fund with CNY 15 billion ($2.1 billion), in which biomanufacturing and new foods are included.

Earlier in the year, the Shanghai Municipal Science and Technology Commission funded seven research projects pertaining to new proteins, including bioreactor design and feedstocks.

The Guangdong Provincial Development and Reform Commission also approved a Synthetic Biology Manufacturing Pilot Platform project in 2025, investing a total of CNY 217.33 million ($30.3 million) toward a four-pronged pilot-scale manufacturing facility, of which two ("functional proteins and other biomacromolecules" and "high-value-added bio-based products") support fermentation-derived food and ingredient production.

While the full scope of China's investment in fermentation research and commercialization is not consistently made public, the announced efforts in 2025 point to a robust, economy-wide effort to provide the industry with the capital and policy support needed to overcome technological hurdles, achieve scale, and gain market share.

India

India's BioE3 policy (Biotechnology for Economy, Environment, and Employment) moved from concept to reality in 2025 with the Department of Biotechnology inviting the first round of proposals for research and startup funding for "smart proteins," the recipients of which are set to be announced in early 2026. This round of proposals emphasizes transformative research to enhance protein production efficiency, safety, and affordability while addressing scalability challenges, all key considerations for developing a robust industry and a stable, diversified food supply.

The Department of Biotechnology has further advanced the BioE3 policy through new funding for high-performance biomanufacturing platforms to advance domestic production and unlock scale. At least three of these biomanufacturing hubs, run by **Laurus Bio**, **HiMedia Laboratories**, and **Sundyota Numandis**, are industry-led fermentation facilities for the production of smart proteins.

A fourth biofoundry, led by the Biotechnology Research and Innovation Council's National Agri-Food and Biomanufacturing Institute, will develop industrial-scale capacity to produce food from single-cell proteins from corn starch sidestreams.

Japan

In November 2025, Prime Minister Takaichi announced the National Growth Strategy, which identifies 17 national strategic sectors for investment, including "food tech," overseen by the Ministry for Agriculture, Forestry and Fisheries (MAFF), and "synthetic biology and biotechnology," overseen by the Ministry of Economy, Trade and Industry (METI). The ministries will submit proposals to the Council for Japan's Growth Strategy, with the plan scheduled to be announced in June 2026.

Research on fermentation-derived foods in Japan continued through several projects funded by the National Agriculture and Food Research Organization's Bio-oriented Technology Research Advancement Institution as well as the Japan Society for the Promotion of Science and the New Energy and Industrial Technology Development Organization.

Throughout 2025, the government has been supportive of working with the private sector through partnerships to advance the industry, as shown by the participation of MAFF, METI, the Japan Science and Technology Agency, and the Consumer Affairs Agency at Cell Ag Week 2025. Government representatives have also discussed the need for biomanufacturing, including fermentation-derived products, at BioJapan, the Global FoodTech Summit SKS Japan, and the Cell Ag Ready Dialogue. Industry associations, including the Japan Bioindustry Association, which advances food biomanufacturing, are also supported by the government.

New Zealand

Two new research projects in New Zealand underscore the promise of fermentation as a key technology to enhance the country's robust agricultural sector and export market. A collaboration with Singapore, funded on the New Zealand side by the Ministry of Business, Innovation and Employment, combines research and private-sector capabilities in both countries to develop new protein products by using biomass fermentation with fruit industry sidestreams, creating new sources of value for farmers and protein for consumers. Meanwhile, the New Zealand Institute for Bioeconomy Science awarded NZD 10.4 million ($6.1 million) to a five-year research program devoted to precision fermentation, including the development of feedstocks made with New Zealand-specific sidestreams. Together, these projects work to boost New Zealand's domestic agricultural sector and position it to benefit from breakthroughs in food technology.

Singapore

Eleven new research projects began through the Singapore Food Agency's (SFA) Future Foods and Food Safety grant programs in 2025, five of which advance the science and safety of fermentation-derived foods.

The projects under the Food Safety Grant Call utilize new methods to proactively ensure the safety and nutrition of precision- and biomass-enabled foods and other foods. The projects under the Future Foods Grant, meanwhile, seek "innovative solutions to strengthen nutrition and functionality of alternative proteins products," including through measuring protein digestibility, using precision fermentation to produce omega-3s and other nutrients, and enhancing the flavor and functionality of microalgae-derived foods. Together, these projects aim to boost consumer demand for sustainable, scalable foods by increasing their appeal and reducing sensory barriers to uptake.

The SFA further supported the development of precision fermentation as a core domestic industry through additional funding for the Centre for Precision Fermentation and Sustainability (PreFerS), a collaboration between the U.S.-based University of Illinois Urbana-Champaign, the National University of Singapore, and the Singapore Institute of Technology. Following the establishment of the Centre with SGD 20 million ($14.8 million) from the National Research Foundation (NRF) in 2024, the additional funding will help scientists "translate research outputs into market ready solutions."

Singapore also continued to collaborate across borders in 2025. NRF's "Catalyst 2025: Strategic New Zealand–Singapore Research Programme" funded a project at universities in both countries to develop mycelial and biomass-enabled protein products from fruit industry sidestreams (see "New Zealand").

Following the establishment of the Bezos Centre for Sustainable Protein at the National University of Singapore, Enterprise Singapore announced a joint startup grant program with the center to fund three alternative protein startups with SGD 150,000 ($116,000) toward anchoring key activities in Singapore.

South Korea

South Korea expanded government support for fermentation in 2025 at several levels, increasing the amount of investments funded through several agencies and working to build the country's infrastructure to better support a future food industry.

The Ministry of Trade, Industry and Energy, the Ministry of Food and Drug Safety, the Ministry of SMEs and Startups, the Ministry of Education, and the Ministry of Science and ICT together began 11 new research projects concerning fermentation in 2025, reflecting a whole-of-government approach to advancing food science and biotechnology.

Policymakers also undertook efforts to build regional food technology hubs in strategic industrial zones. The municipal government of Iksan City and Jeonbuk Province jointly announced the creation of a Jeonbuk Innovation Success Venture Fund with KRW 30 billion ($20.8 million) to support food technology companies based in the region, including fermentation-derived and other alternative proteins. Jeonbuk Province also signed a Memorandum of Understanding with the Embassy of the Netherlands in Korea to jointly promote all three new protein production systems.

Thailand

In a bid to establish Thailand as a regional hub for advanced manufacturing and innovation, in 2025 the government announced THB 5 billion ($153 million) in funding to support upskilling at least 100,000 people to work in "biotechnology, advanced agriculture, electronics, food processing and medical devices," among other key areas. The government plans to work with investors and manufacturers to develop curricula and identify areas of need, targeting both university students and the current workforce.

In July 2025, the Program Management Unit for Human Resources & Institutional Development, Research and Innovation, a government research agency, announced a bilateral research call with the Japan Science and Technology Agency on "Precision Fermentation Technologies for Alternative Foods and Functional Molecules" and two other topics. Selected projects will be announced in March 2026.

Further, two of the food tech startups selected for the fifth cohort of the SPACE-F incubator focus specifically on fermentation for food. Backed by the Ministry of Higher Education, Science, Research, and Innovation, with Mahidol University, **Thai Union**, **Nestlé**, and other private-sector co-funders, the incubator guides promising companies through fundraising and product development.

Europe

European Union

Amid a broader push in biotechnology and biomanufacturing, the European Union took concrete steps to support fermentation-enabled food production in 2025, building on the groundwork laid in 2023 and 2024 by the European Innovation Council (EIC) and the European Investment Bank (EIB).

In 2025, the European Commission published two strategies outlining the policy direction and priorities for sectors relevant to fermentation: the Life Sciences Strategy and the Bioeconomy Strategy. In both, advanced fermentation is positioned as a key technology with applications across multiple sectors, including food, signaling growing momentum for food biotech and related innovations alongside commitments to remove bottlenecks. The Life Sciences Strategy highlighted the potential of advanced fermentation and pointed to better collaboration initiatives and new research and innovation funding opportunities. The Bioeconomy Strategy announced measures to improve regulatory and technical support for fermentation innovators, support scale-up infrastructure, and mobilize investment to help bring fermentation-made products to market.

The EIB offered multiple large loans to businesses across the technology spectrum, including a €35 million ($36 million) loan to Germany's **Formo** to produce biomass- and precision-enabled cheese at scale. Additionally, the EIC supported **MOA Foodtech**, a Spanish fermentation startup, with a €14.9 million ($15.4 million) investment commitment, consisting of a €2.3 million ($2.4 million) grant and €12.5 million ($13 million) in equity funding, the latter of which is contingent on matching co-investments from private investors.

The EIC also awarded much of the funds set aside through the EIC Work Programme 2024 for scaling up the production of food from fermentation and algae to startups across the bloc, advancing the science and commercial potential of precision, biomass, and gas fermentation. Further research was funded by the EU's Horizon Europe program at universities and public research organizations under research calls concerning "Sustainable micro-algae as feedstock for innovative, added-value applications" and "Innovative bio-based food/feed ingredients," as well as through non-specific research programs supporting scientific advancement more generally. Horizon Europe also funded APRISE (Alternative Proteins Research and Innovation Skills Enhancement), a project to provide workforce development, technical training, and shared resources with countries without strong food tech sectors, including Greece, Malta, North Macedonia, Poland, and Türkiye.

The Sustainable Blue Economy Partnership further added to the list of ongoing EU-funded research with two projects evaluating microalgae and biomass fermentation of seaweed for alternative seafood. In total, various programs operated by European Union institutions announced nearly €70 million ($82 million) in new grants for fermentation research and commercialization efforts, excluding the nearly €50 million ($58.6 million) offered through loan programs.

Denmark

Denmark expanded the country's ongoing leadership in advancing plant-based protein sources with an additional policy focus on fermentation-derived proteins in 2025. The Green Development and Demonstration Programme announced two new precision fermentation projects, while Denmark's AgriFoodTure research program announced several new projects supported by NextGeneration EU's Recovery and Resilience Facility.

The Danish government also earmarked approximately DKK 460 million ($73.3 million) in funding for biosolutions between 2026 and 2029, and DKK 100 million ($15.7 million) in 2026 alone, through the Innovation Fund Denmark, a funding opportunity expected to include food production from fermentation. In 2025, the Danish Alliance for Biosolutions, a partnership created by and housed under the Danish Chamber of Commerce, launched a "Biosolutions Forum+" to accelerate the development of future foods and their regulatory path to market, including stakeholders from science, industry, and government.

Estonia

Estonia, a growing hub for startups and entrepreneurs, awarded local startup **ÄIO** €1 million ($1.1 million) to speed up the development of their yeast-derived sustainable fat alternative. Though early products are intended for the cosmetics and personal care industries, the company has also developed products to replace animal fats in food products.

Finland

A government-commissioned report from the VTT Technical Research Centre found that cellular agriculture, including fermentation, presents the country with an economic opportunity of up to €1 billion and recommended a five-year, €100 million research, development, and innovation program to advance the sector, in addition to regulatory support, workforce development, and the establishment of a Ministry of Future Food.

Finland's trade and investment agency, Business Finland, has provided a model of the necessary government support since 2022, when it awarded €33.6 million ($36 million) in funding to gas fermentation company **Solar Foods** for their pilot-scale Factory 01. In 2025, Business Finland reiterated support for the development of domestic biomanufacturing capacity, granting an additional €10 million ($10.5 million) in February 2025 to support planning for Factory 02 in Lappeenranta, which will boost production capacity 40x. Backed by the European Union's Hydrogen Important Project of Common European Interest state aid scheme, Solar Foods is eligible to receive up to €110 million ($115 million) in public grant funding through 2036.

Netherlands

In January 2025, the Dutch National Growth Fund announced €12.5 million ($12.9 million) toward building the Biotechnology Fermentation Factory, an open-access precision fermentation scale-up facility, alongside an existing pilot plant in Ede. The facility is expected to be fully operational by the end of 2026.

Norway

The Research Council of Norway began three new research projects in 2025 to advance the science of fermentation, including producing omega-3 nutrients through microalgal fermentation, evaluating consumer attitudes in Asia toward fermentation-enabled foods, and scaling up sustainable production and biorefining of key nutritional proteins.

Spain

The Regional Government of Valencia awarded €472,000 ($555,000) to public research center IATA-CSIC and the University of Valencia for the YEAST4VALUE project, which will develop ways to use sidestreams from the rice, wine, olive oil, and horchata industries as feedstocks for precision fermentation. The Province of Tarragona in Catalonia also awarded a grant of about €50,000 to **Eurecat** for a project on gene editing for precision fermentation.

Sweden

The Swedish Research Council began a new research project in 2025 to advance the science of fermentation: "Sustainable protein from gas fermentation: Advancing cultivation efficiency and functional performance in complex food matrices," at KTH Royal Institute of Technology. KTH launched an initiative through a call for projects addressing "contingency planning and competitiveness in the food system." Funded by The Research Council for Environment, Agricultural Sciences and Community Building, the PLENTY research center, backed by SEK 85 million ($8.5 million), will use fermentation and other technologies to valorize agricultural byproducts and strengthen Swedish food resilience.

Switzerland

Public research organizations in Switzerland funded two new research projects concerning fermentation-derived dairy products in 2025. Both research projects investigate the valorization of existing dairy-industry sidestreams through microalgal fermentation, enhancing the nutrition and sustainability of otherwise underutilized resources.

United Kingdom

The UK's Modern Industrial Strategy was published in summer 2025, with the Digital and Technologies Sector Plan allocating an initial £184 million ($249 million) for engineering biology scale-up infrastructure. This funding could support the creation, retrofitting, and expansion of production facilities for fermentation over the rest of the decade. In late 2025, the UK Government confirmed that overall funding for engineering biology would increase threefold to £644 million ($872 million).

Innovate UK continued to support R&D through the UK's private sector with a grant to UK biomass fermentation company **Adamo Foods**, in collaboration with **Givaudan** and the University of Nottingham, for a joint research project to use AI to perfect the flavor of their product.

Middle East

Israel

In 2025, the Israel Innovation Authority (IIA) directed approximately NIS 90 million ($28 million) to food technology programs, of which around NIS 49.5 million ($15.5 million) specifically targeted alternative proteins. These investments were aimed at strengthening Israel's capabilities in areas such as food biotechnology, precision fermentation, and artificial intelligence, all situated within a rapidly scaling climate technology ecosystem. By the end of 2025, cumulative investments from the IIA in alternative proteins reached approximately NIS 325 million ($100 million). While the portion of the 2025 funding allocated to fermentation was not available at the time of publication, past Israeli investments have ranged across all three production methods while maintaining focus on biotechnology. In particular, as a result of ambitious investments to build a scientific network and necessary infrastructure in precision fermentation milk and dairy, Israeli companies have led the global sector in launching new products and scoring regulatory green lights.

Note: All information on IIA investments and priorities was provided directly to GFI Israel.

Regulation

Most governments have well-established regulatory systems for products made with fermentation in the food system. In 2025, countries across the world took meaningful steps to more precisely define how novel fermentation-enabled proteins, particularly those created using biomass and precision fermentation, should be regulated and brought to market.

Australia/New Zealand

In June 2025, Food Standards Australia New Zealand (FSANZ) introduced new definitions in the Food Standards Code for "genetically modified [GM] food" and "novel DNA" that addressed precision fermentation products. The new definitions will continue to treat precision fermentation products derived from microorganisms that contain novel DNA as GM foods, but exempt additives and processing aids created using precision fermentation and GM organisms from the GM food definition, since they are already regulated separately in the code. As such, the updated code says that precision fermentation products derived from microorganisms that contain novel DNA will be considered GM foods and may be subject to premarket regulation.

In December 2025, FSANZ accepted Australia's first novel food application for a precision-fermentation ingredient, submitted by **Eden Brew** for the company's animal-free beta-casein protein preparation. FSANZ's evaluation of the ingredient is anticipated to take less than one year and include one round of public consultation.

China

China continues to regulate novel fermentation-enabled products and ingredients through a premarket approval system administered by the National Health Commission (NHC), with the National Center for Food Safety Risk Assessment conducting safety assessments. As of July 2025, the NHC had accepted 26 novel food applications, including applications for fermentation-enabled ingredients.

European Union

In July 2025, the European Commission published its Life Sciences Strategy that identifies ways the EU can drive innovation, facilitate market access, and build public trust in new technologies, including precision and biomass fermentation technologies that offer "significant potential" for producing quality products from renewable materials with low environmental impact.

Following several months of debate and negotiations in 2025, EU policymakers agreed in March 2026 to ban the use of the word "meat" and 31 meat-related terms for plant-based, fermentation-enabled and cultivated options despite consistent survey results demonstrating that European consumers support the use of these terms for alternative protein products. When the restrictions come into force, companies will no longer be able to use everyday terms such as "steak" and "chicken" to describe their fermentation-enabled products. Lawmakers agreed to a three-year transition period to enable companies to sell existing stock and adapt to the restrictions. At the time of writing, the text is also subject to final adoption, including a vote in the European Parliament.

In November 2025, the Netherlands became the first EU country to issue a code of practice for public tastings of foods produced using precision and biomass fermentation. Companies who wish to host tastings prior to receiving full product approvals must submit detailed applications to an independent Expert Committee for review. In December, Dutch company **The Protein Brewery** received the EU's first positive European Food Safety Authority scientific opinion for a new mycoprotein ingredient, confirming the product is considered safe under proposed conditions of use. The final step now lies with the European Commission and EU member states, who will decide whether to authorize the new ingredient and add it to the EU's list of novel foods, allowing it to be sold across the Union.

Japan

In November 2025, the Japanese government held the first meeting of the Japanese Growth Strategy Headquarters, where it announced 17 priority sectors, including food tech. The Minister of Agriculture, Forestry, and Fisheries will oversee the food tech sector, which includes precision fermentation products and mycoproteins, and lead the formation of a public–private investment roadmap for the sector. The roadmaps are meant to promote regulatory reform and market expansion.

South Korea

In December 2025, South Korea enacted the Food Tech Industry Promotion Act, establishing a legal and administrative framework for the Ministry of Agriculture, Food, and Rural Affairs (MAFRA) to support innovative food products, including fermentation-enabled products. The Act empowers MAFRA to provide direct support to businesses, offer startup assistance, facilitate access to research facilities and equipment, and foster market entry.

The Act also allows MAFRA and companies to collaborate to address regulatory bottlenecks, rather than having companies navigate the regulatory process independently.

Also in 2025, the Korean Ministry of Food and Drug Safety commissioned a study on Safety Assessment Methods for Novel Food Ingredients Produced Using Precision Fermentation Technologies, signaling that the government may soon begin developing guidelines to approve precision fermentation ingredients.

Singapore

In January 2025, Singapore enacted the Food Safety and Security Act, formally codifying the Singapore Food Agency's premarket approval process for novel foods, including proteins from biomass and precision fermentation, under a new "defined foods" category. Companies can now reference a clear regulatory category with corresponding legislation to identify the pathway to market for these products, rather than relying solely on policy guidance. The Act will be implemented in phases from late 2025 through 2028.

In March 2025, Singapore updated its novel foods safety assessment guidance to clarify and standardize approval expectations for fermentation-enabled proteins, including an estimated nine to 12 month review timeline and regulatory submission checklists. In November 2025, Singapore further signaled its continued engagement with novel foods by convening its annual Roundtable on Novel Foods Regulation, bringing together international regulators, industry, and academia to discuss the safety assessment and oversight of biomass and precision fermentation products.

Thailand

Thailand's Office of the National Higher Education, Science, Research, and Innovation Policy Council (NXPO) identified alternative proteins as one of Thailand's core future food policy priorities at an expert forum convened in January 2025. In November, NXPO issued a report identifying development opportunities for Thailand's alternative protein industry, specifically noting strengths and gaps for fermentation-derived proteins.

Also in 2025, NXPO participated in an expert forum with the Agricultural Research Development Agency and the Program Management Unit for Competitiveness to begin establishing functional claims for future foods, including alternative proteins. Expanding the available claims is expected to create a more favorable environment for alternative protein products, including fermentation-enabled products, positioned around the functional benefits of specific ingredients.

United Kingdom

In 2025, the Food Standards Agency and Food Standards Scotland launched their Market Authorisation Innovation Research Programme (IRP) for fermentation technologies. The IRP is a one-year program, backed by £1.4 million in funding from the Department for Science, Innovation, and Technology, designed to enhance the regulator's expertise in the food safety risks of innovative technologies, with a specific emphasis on fermentation. The program also directly supports fermentation companies considering market authorization in Great Britain by offering a dedicated Business Support Service. This service complements the Innovate UK-funded Novel Foods Expert Network, which provides resources and guidance to businesses seeking a novel food authorization in the UK.

United States

In the United States, companies continued to have two regulatory pathways to bring novel fermentation-derived foods and ingredients to market in 2025. First, companies may submit a food additive petition to the U.S. Food and Drug Administration (FDA) which may then issue a regulation authorizing specific uses of the ingredient. This process is generally time-intensive.

The second pathway is to establish that an ingredient is Generally Recognized as Safe (GRAS) by qualified experts for its intended use. Companies can bring a product to market as soon as they establish this, but it is best practice to submit a GRAS notice to FDA upon making this determination and wait until FDA issues a "no questions" letter in response, indicating that the agency does not question the experts' safety conclusion. Fermentation companies typically elect this GRAS pathway to market over submitting a food additive petition, as demonstrated by the numerous companies who received "no questions" letters in 2025.

In late 2025, FDA sent a proposed rule that would amend the GRAS process to the Office of Management and Budget for review, following critiques of the GRAS process by U.S. officials. This is the final step in the government clearance process before the proposed rule gets released to the public for comment. The proposed rule is expected to require companies to notify FDA that they have a positive GRAS determination for an ingredient, including for both new and existing substances, before the ingredient can come to market. Once the proposed rule is made available to the public, FDA will solicit comments and potentially incorporate feedback into the rule.

Fermentation GRAS “no questions” letters in 2025

By production method and ingredient type

Production method	Ingredient	Company (HQ)	Specific ingredient	Production strain	“No questions” letter date	GRN number
Precision fermentation	Dairy protein	**Vivici** (Netherlands)	Beta-lactoglobulin	*Komagataella phaffii*	February 2025	GRN 1200
		TurtleTree (Singapore)	Lactoferrin	*Komagataella phaffii*	May 2025	GRN 1219
		Changing Bio (China)	Beta-lactoglobulin	*Kluyveromyces lactis*	September 2025	GRN 1247
		Verley (France)	Beta-lactoglobulin	*Aspergillus oryzae*	September 2025	GRN 1241
	Heme protein	**Impossible Foods** (U.S.)	Soy leghemoglobin	*Komagataella phaffii*	March 2025	GRN 1202
	Egg protein	**Onego Bio** (U.S., Finland)	Egg protein	*Trichoderma reesei*	September 2025	GRN 1249
	Sweet protein	**Nanjing Bestzyme** (China)	Brazzein	*Aspergillus oryzae*	May 2025	GRN 1207
		Oobli (U.S.)	Brazzein	*Komagataella phaffii*	September 2025	GRN 1142*
Biomass fermentation	Yeast protein	**Changing Bio** (China)	Yeast biomass	*Kluyveromyces marxianus*	September 2025	GRN 1248
	Mycoprotein	**MoreMeat** (China)	Mycelial biomass	*Fusarium compactum*	November 2025	GRN 1255

Source: GFI analysis of the FDA GRAS Notices Inventory.

*Oobli received a supplemental "no questions" letter for a strain modification to their GRN1142 notice.

Conclusion

The world's biggest challenges—climate, public health, food security—are all connected to how we currently produce meat. To address those challenges, we must diversify how meat is made.

Fermentation-derived meat offers one way to do exactly that. Today, the fermentation-derived protein industry comprises approximately 430 companies—a mix of specialized companies focused primarily on fermentation for alternative proteins and diversified companies involved through investments or partnerships. This represents a minuscule fraction of the global conventional meat industry. But consider this: Substituting just 20 percent of beef with fermentation-enabled meat could cut deforestation in half by 2050.

Innovation and investments that accelerate consumer adoption remain a must. In 2025, public investments in the bioeconomy were seen around the globe, with many calling out fermentation specifically as a strategic investment in food security and sovereignty. And even amid a challenging funding environment and labeling roadblocks that restrict consumer choice, innovators in the field pressed on, partnering to build on existing knowledge and maximize viability and efficiency.

In the critical years ahead, there are choices to make that will determine our collective food future. What path will we go down and what will that path look like? A few reflections on imagining a sustainable future, as we lean into the work ahead together:

We can choose a path where meat is made in vastly more sustainable, secure, and safe ways.

There is a path that respects people's food choices and offers options with far fewer adverse impacts than conventional meat. In concrete terms? This looks like friends and families gathered around tables enjoying delicious, nourishing meals that include their favorite foods made in ways they feel good about.

We can choose a path where the meat we eat enables nature to rebound and health to rise.

As meat demand grows, continuing to produce it in status quo ways takes us down a path with zero chance of reducing emissions and reversing biodiversity loss. There is another choice, where, compared to conventional meat production, the meals we eat actually strengthen public health and help protect the natural world.

In concrete terms? This looks like a delicious fermentation-derived steak used in a favorite everyday recipe, all while nature recovers and pandemic-triggering conditions are no longer part of our global food system.

We can choose a path that builds a thriving world, fed sustainably.

There is a path that leads to abundance, not scarcity. We can build a better food system for all, one that feeds a population nearing 10 billion while mitigating multiple risks at once.

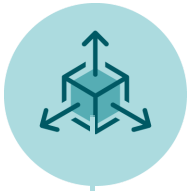
On that path, fermentation-derived meat will need several things: more public investment from governments around the world, more policies that support consumer choice and fair labeling, more research centers and scientific collaborations, and more partnerships between corporations and startups to de-risk scale up.

Multiple interventions will be needed to transform food systems at the pace and scale needed to feed a growing world. As a nonprofit, GFI is committed to moving the entire sector forward. We are helping to build a path where delicious, affordable meat and seafood are made in ways that are far more sustainable, secure, healthy, and safe. With the right levels of support, fermentation-derived meat—as well as meat made from plants or cultivated from animal cells—can be a core food system solution, helping us tackle the biggest challenges of our time.

About GFI

The Good Food Institute is a nonprofit think tank working to make the global food system better for the planet, people, and animals. Alongside scientists, businesses, and policymakers, GFI's teams focus on making plant-based, fermentation-enabled, and cultivated meat delicious, affordable, and accessible. Powered by philanthropy, GFI is an international network of organizations—working across Asia Pacific, Brazil, Europe, India, Israel, and the United States—advancing alternative proteins as an essential solution needed to meet the world's climate, global health, food security, and biodiversity goals.

We focus on three programmatic priorities:



Cultivating a strong scientific ecosystem

We map out the most neglected areas that will allow alternative proteins to compete on taste, price, and nutrition. We meet these challenges by developing open-access research and resources, educating and connecting the next generation of scientists and entrepreneurs, and funding open-access research across the sector.

Influencing policy and securing public investment

We ensure that alternative proteins are a part of the policy discussion around climate and biodiversity, global health, future-resilient jobs and bioeconomies, and food security. In every region where we have a presence, we advocate for public investment for open-access research on alternative proteins, and increasingly, we work to advocate for government resources to support scale up and commercialization. We also advocate for fair and transparent regulatory frameworks for assessing safety and product labeling.

Engaging with industry to advance alternative proteins

We work to replicate past market transformations by showing companies of all sizes, from startups to multinationals, the benefits of protein diversification and how alternative proteins can enable businesses to succeed while meeting sustainability goals. We conduct research and share insights to educate the public on alternative proteins and champion their adoption by the food industry, including manufacturers, retailers, restaurants, investors, and more.

All of GFI's work is made possible by gifts and grants from our global community of donors. If you are interested in learning more about giving to GFI, contact philanthropy@gfi.org.

In 2026, GFI marks its 10th year. That's 10 years of impact—from a simple idea (can meat be made differently?) to a global and growing ecosystem of innovators making it happen. To learn more, check out our special 10th anniversary edition Year in Review, which marks how far the field has come and points to the important work ahead.