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FERMENTATION, MYCOPROTEIN, CELLULAR AGRICULTURE

Sustainable solutions for food production

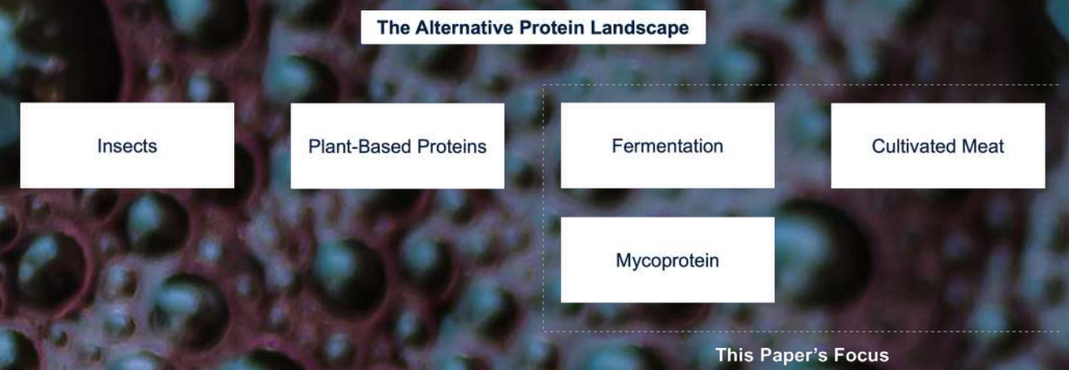
CONTENT

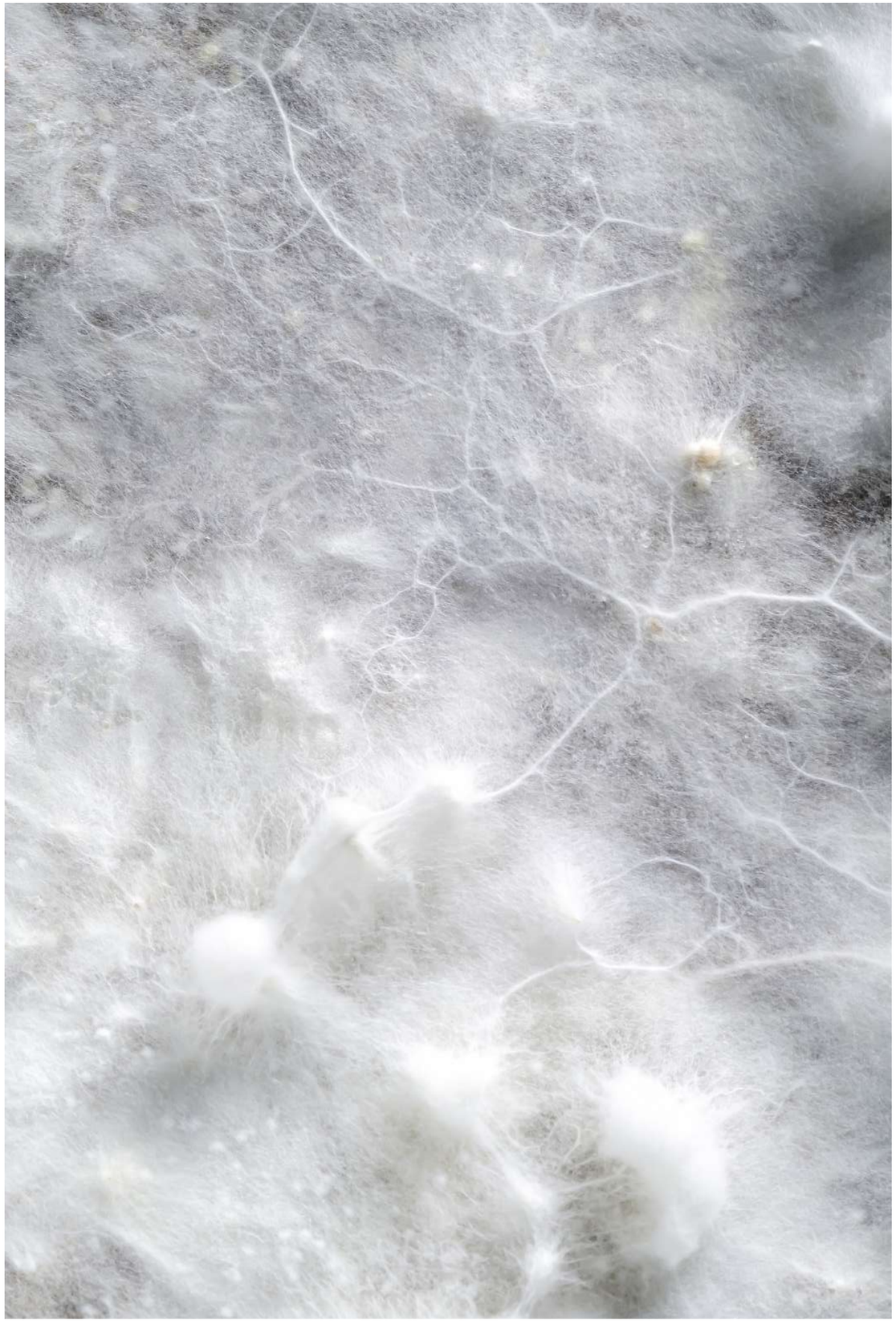
Although start-up companies raised EUR3.7bn in the fermentation, mycoprotein and cellular agriculture sectors in 2021 and 2022, at least twice as much will be required for them to unlock their full potential.

The growing global population points to a 70% rise in food production and a 78% increase in protein demand by 2050. Urgent solutions are needed to bring safe, nutritional foods to populations while combating climate change. Livestock production is indeed responsible for around 15% of global greenhouse gas emissions and sustainable alternatives are needed.

Fermentation has been present in our lives for centuries, but still has plenty to bring to the table, supported by the huge strides made in technology and science. This paper dives into the different technologies being developed, from traditional fermentation to cellular agriculture, and including biomass, precision and microbial fermentations as well as new usages of mycelium. We explore how these techniques can be used to sustainably produce innovative ingredients, replicate animal proteins, or create a whole new food product. We also explore other consumer applications for fermentation technologies, especially in the beauty and fashion spaces.

Regulations and infrastructure are dragging on this transformative field, particularly in Europe, where safety authorities are lagging behind their US, Israeli and Singaporean peers in adopting Novel Foods products, leading innovators to seek approval elsewhere, and ultimately causing innovation leadership loss in the region. Meanwhile, less than 1% of bioreactor capacities needed for food fermentation is likely to be live by 2030 on a global scale, implying a shortage that will only be resolved if all actors - governments, large companies and investors - work hand in hand to help start-ups mature.





METHODOLOGY

SECTION 1

METHODOLOGY

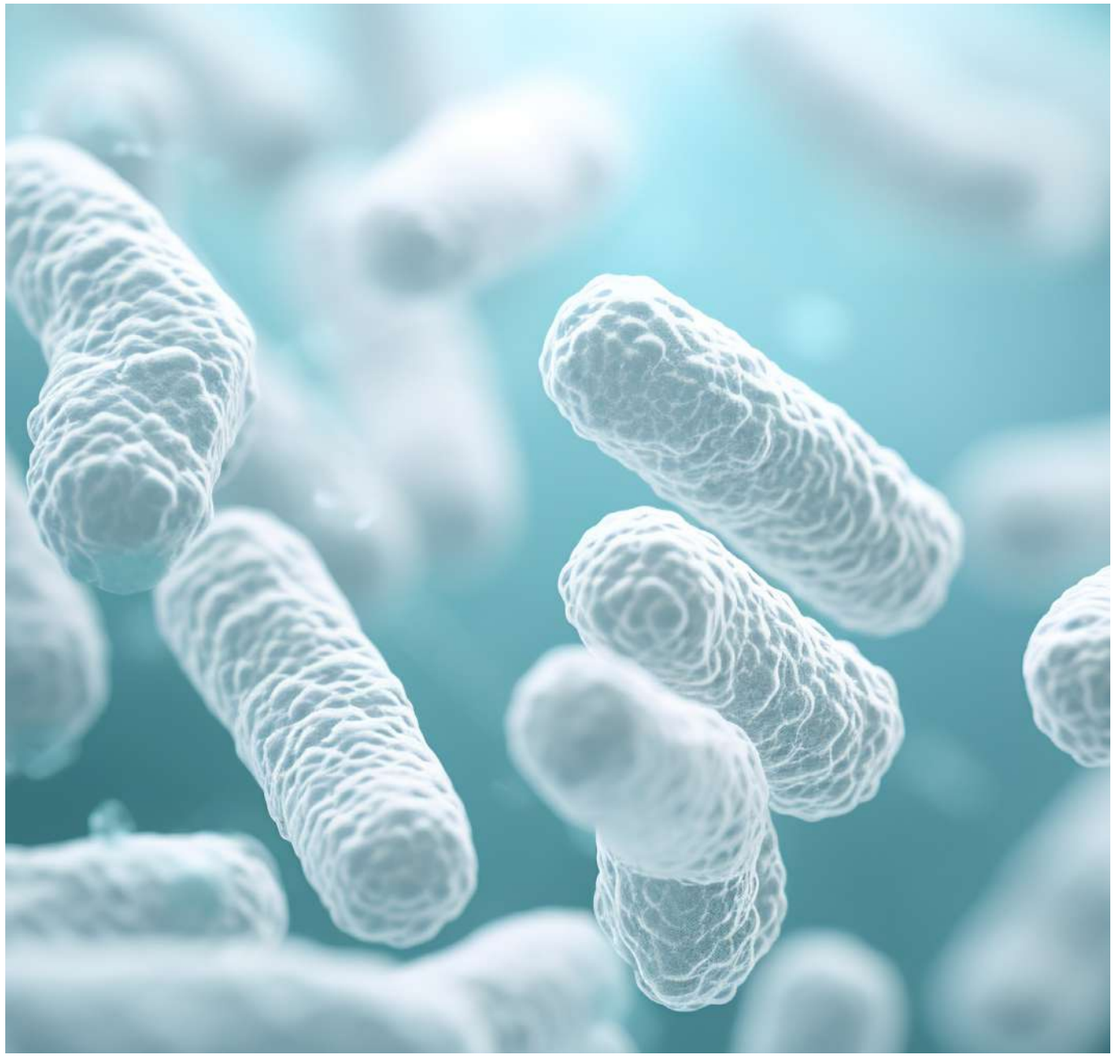
In our research for this white paper, we had conversations with several companies active across the three segments covered: fermentation, mycelium, and cellular agriculture. The following table outlines the companies we spoke to and their fields of activity. Our conversations are presented in greater detail through case studies in the relevant sections of this paper. The two companies referred to separately as “biomanufacturing” in the table are specialised service providers focused on biological processes rather than production of specific outputs.

FIG 1: COMPANIES REFERENCED IN THE PAPER AND THEIR FOCUS AREA

	Fermentation	Mycelium	Cellular Agriculture	Biomanufacturing
Aleph Farms			•	
Bon Vivant	•		•	
Bonumose	•			
CellRev				•
ENOUGH		•		
Geno	•		•	
GOURMEY			•	
Hoxton Farms			•	
Kinoko Tech		•		
Mermade Seafood			•	
MOA Foodtech	•			
MOGU		•		
Mushlabs		•		
Mycorena		•		
Paleo Taste	•			
Quorn		•		
Revyve (FUMI Ingredients)	•			
Solar Foods	•			
Standing Ovation	•			
Synonym				•
The Protein Brewery	•	•		
Väcka	•			
Vital Meat			•	
VitroLabs			•	

INTRODUCTION

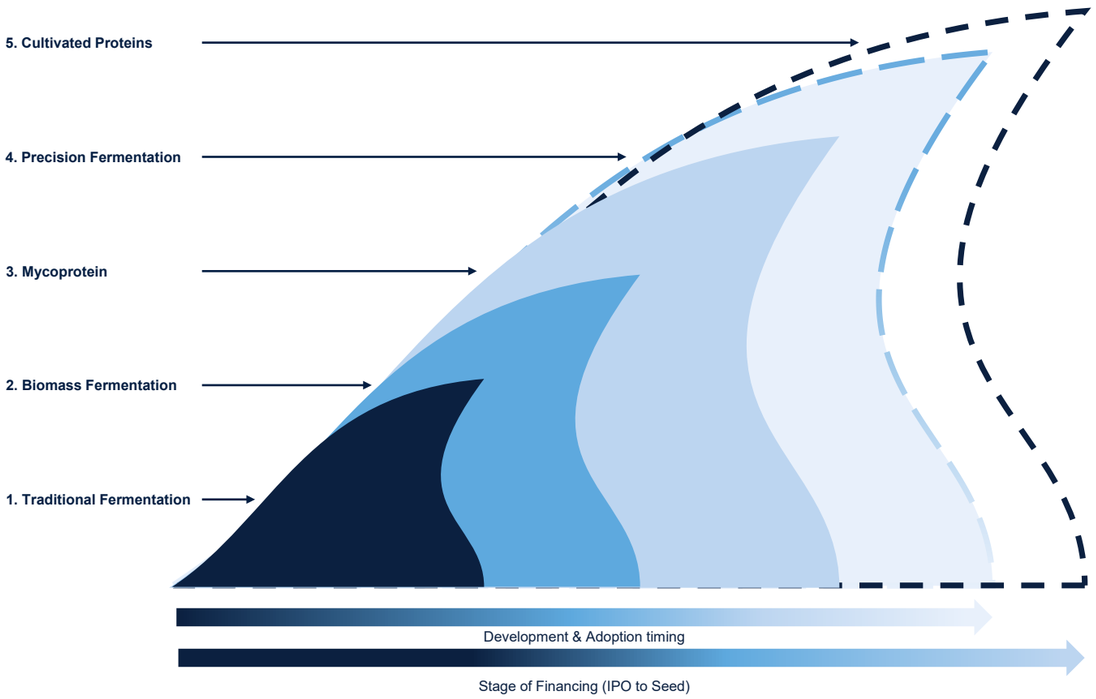
SECTION 2



INTRODUCTION

A brief history of fermentation

FIG 2: DEVELOPMENT AND FINANCING STAGES IN FERMENTATION



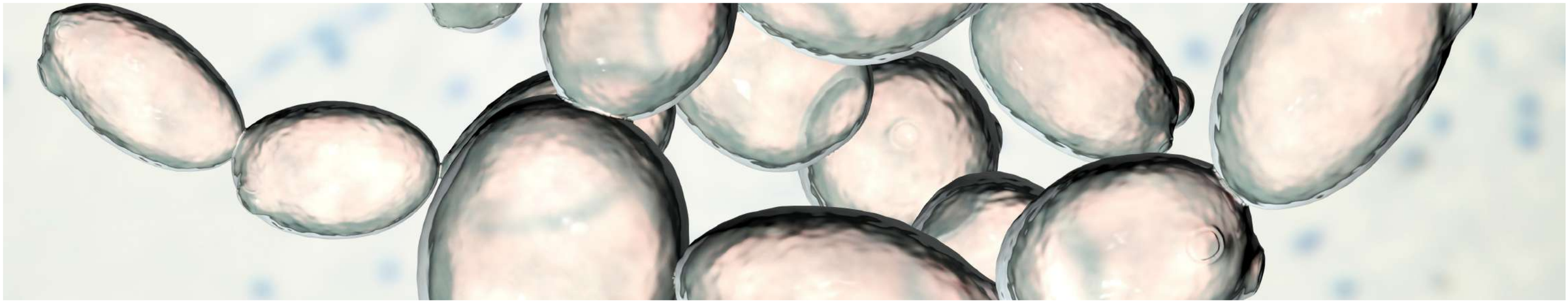
Traditional fermentation has been part of our lives for centuries now, through the production of bread, wine, and cheese. Companies present in traditional fermentation applications are generally large and well-funded (AB InBev, Bel, Danone…).

A common use case of **biomass fermentation** (multiplication of biomass through fermentation to produce large quantities of products) is biogas as well as wastewater treatment. However, when applied to food, it can enable large scale production of alternative proteins. Several plant-based protein companies have started to introduce fermentation to their processes, such as Impossible Foods or Planted. Biomass fermentation can be extended into microbial fermentation, with Air Protein and Solar Foods leading the field, having raised EUR95m and EUR42m respectively.

The development of mycoproteins (edible proteins or ingredients deriving from mycelium) is a story of two worlds: Quorn enjoyed stellar expansion as of the 1960s and set a precedent for the second wave of mycelium companies that started in the late 2010s after the patent expired. Despite the small number of companies present in the area, the amounts raised are reaching significant levels, with Meati raising USD275m and Scotland's ENOUGH securing EUR55m in 2022 (and an additional EUR40m in 2023).

Precision fermentation (engineered microorganisms to achieve specific goals and replicate specific proteins) has attracted a lot of interest recently with some US companies very well-funded, such as Perfect Day (EUR617m raised in total) or EVERY (EUR240m raised to date). The former received a GRAS "no question" letter in 2020 and has signed several partnerships with leading staples (Nestlé, Bel, Mars, Brave Robot). Developments are still early in Europe, but regulatory easing is expected to follow after progress made in the US and Israel, where Remilk secured regulatory approval in early 2023.

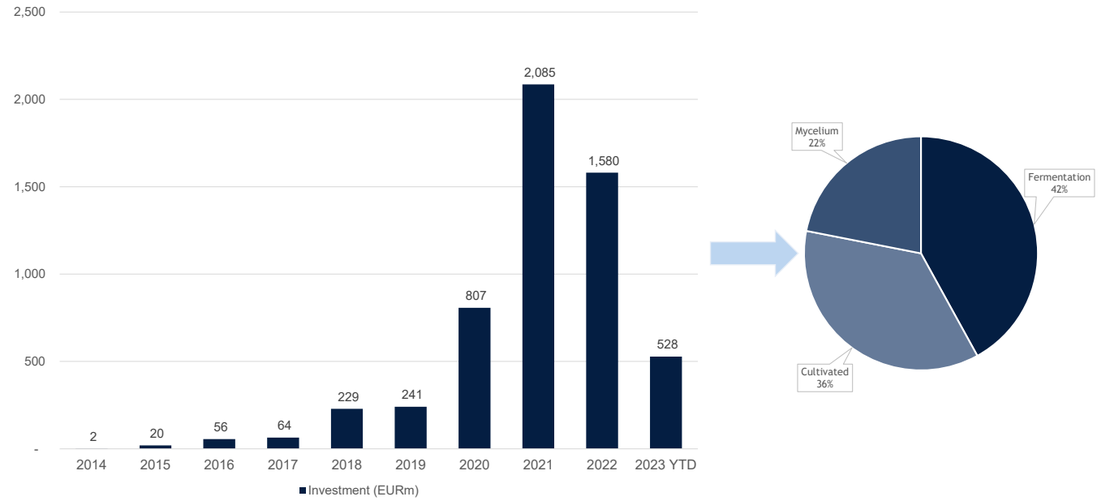
Finally, **cellular agriculture** (use of stem cells to synthetically replicate proteins, fats or tissues) has gained significant momentum over the past decade and the regulatory approvals obtained in Singapore and the US are set to drive progress to the commercialisation phase. Companies operating in the most regulatory-friendly countries are also better funded, as shown by the difference between money raised in the US (USD700m) and Europe (EUR236m). The extensive need for R&D and infrastructure in cultivated proteins creates an extended need for capital.



Investor playbook

Since 2013, EUR5.6bn has been invested across fermentation, mycelium and cellular agriculture start-ups, EUR5bn of which since 2020. With EUR530m raised over the first six months of the year, 2023 got off to a strong start.

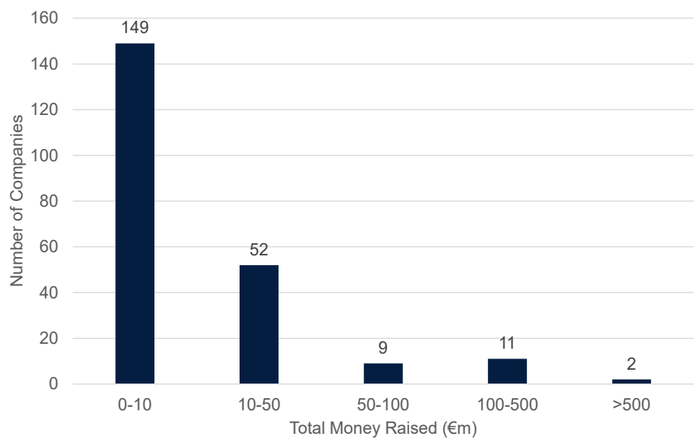
FIG 3: TOTAL INVESTMENT IN FERMENTATION SINCE 2014, AND BREAKDOWN BY FERMENTATION, MYCELIUM AND CELLULAR AGRICULTURE, AS OF 19TH JUNE 2023



Source: Stifel using Pitchbook's Data*
Note: Quorn is excluded from the Mycelium screen

Despite positive investment momentum, the total amount raised by companies present in the field remains limited, with most start-ups having raised less than EUR10m.

FIG 4: BREAKDOWN OF MONEY RAISED IN THE INDUSTRY



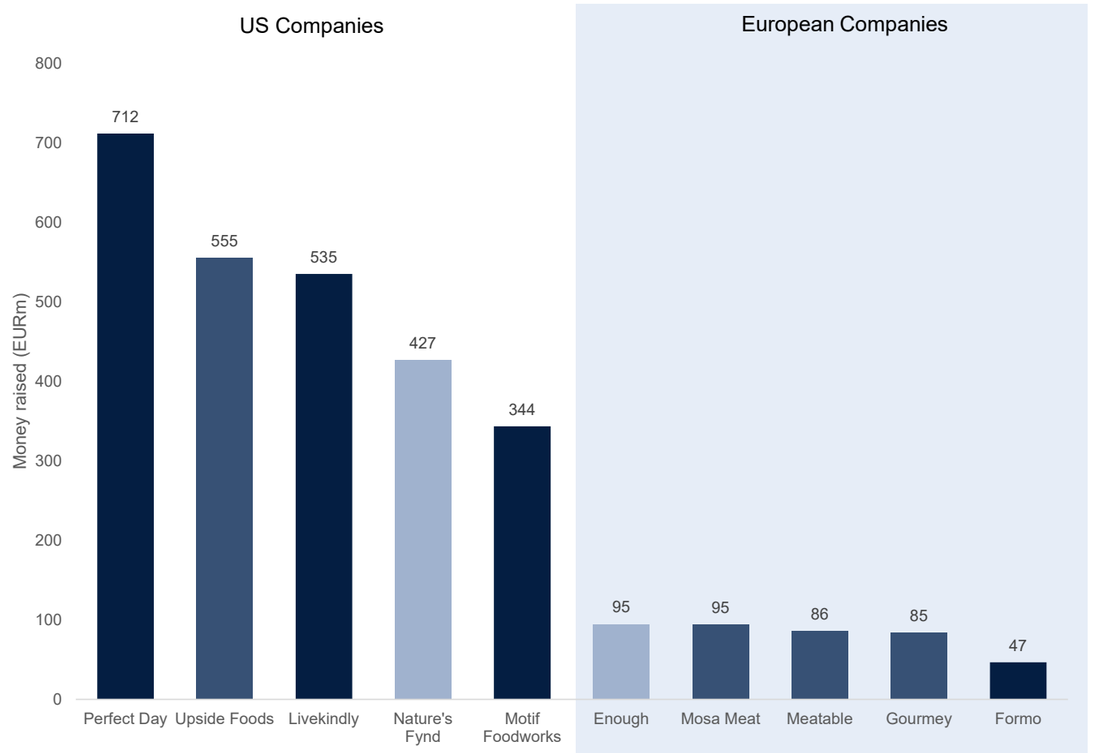
Source: Stifel using Pitchbook's Data*
Note: Quorn is excluded from the Mycelium screen

Exceptions exist, especially in the US where several companies have achieved significant raises. Israeli companies such as Believer Meats (EUR345m) or Remilk (EUR131m) are also well funded.

Despite accounting for 25% of the companies screened for this paper, Europe is still lagging from a financing standpoint. **The Top 5 European start-ups have raised an average of 6x less than their American counterparts.**

Since the start of 2023, European companies have attracted renewed interest from investors and raised EUR150m during the first half, with Cubiq Foods (EUR50.4m), Uncommon (ex- Higher Steaks, EUR28.3m) and Paleo (EUR12m) leading the way.

FIG 5: BEST FUNDED COMPANIES IN THE US VS EUROPE

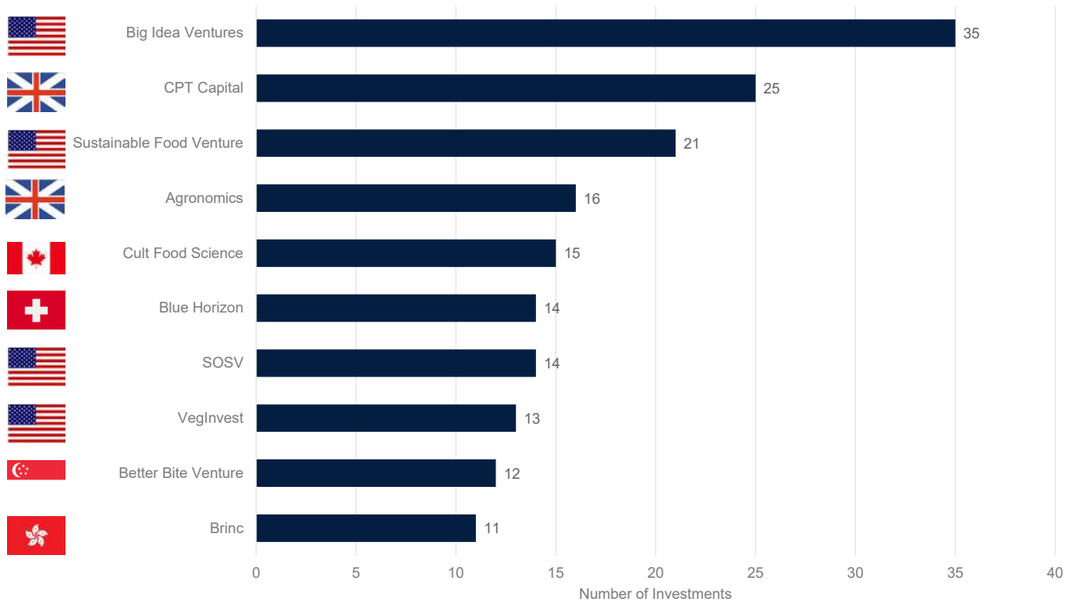


Source: Stifel using Pitchbook's Data*

From an investor standpoint, funds investing in the fermentation space are either specialised in the alternative proteins space or generalists. Biotech investors have limited presence in the field at this point.

Most investors are still based in the US. A sharp increase in European investors' presence will be required to accelerate local developments and support European start-ups as they grow to compete on a global scale.

FIG 6: TOP 10 INVESTORS IN FERMENTATION, MYCELIUM AND CELLULAR AGRICULTURE



Source: Stifel, Company Reports*
Note: This count only takes companies acting in the food space and may therefore exclude companies that offer Technology, Infrastructure or work on non-food applications

As fermentation is attracting more interest from venture capital and private equity funds, large corporates in the staples and ingredients sectors are also starting to invest heavily in start-ups operating in attractive verticals. For example, Danone is backing ImaginDairy (precision fermentation) and Wilk (cultivated agriculture), while Tyson is investing in MycoTechnology's mycelium solutions.

FIG 7: LARGE CAPS INVESTMENT ACROSS FIELDS

	Fermentation	Mycelium	Cellular Agriculture
Danone	• ImaginDairy		• Wilk
Nestlé	• Perfect Day		
Bel	• **Standing Ovation** Superbrewed		
General Mills	• Remilk		
Kraft Heinz	• New Culture		
JBS			• BioTech Foods (Acquired)
Tyson		• MycoTechnology	• UPSIDE Foods Believer Meats
BRF			• **Aleph Farms**
Hormel		• The Better Meat Co.	
Cargill		• **ENOUGH Foods**	• UPSIDE Foods Cubiq Foods **Aleph Farms** Wildtype Memphis Meat
ADM	• New Culture (Partnership) Air Protein Perfect Day Geltor	• Nature's Fynd	• Believer Meat
DSM-Firmenich	• **Paleo** Vivici Phytolon		
VitroLabs			

BG IRIS Coverage

FERMENTATION: OLD BROTHS PROVIDE GREAT INNOVATIONS

SECTION 3

FERMENTATION: OLD BROTHS PROVIDE GREAT INNOVATIONS

FIG 8: AN OVERVIEW OF THE FERMENTATION MARKET

*Source: Stifel**

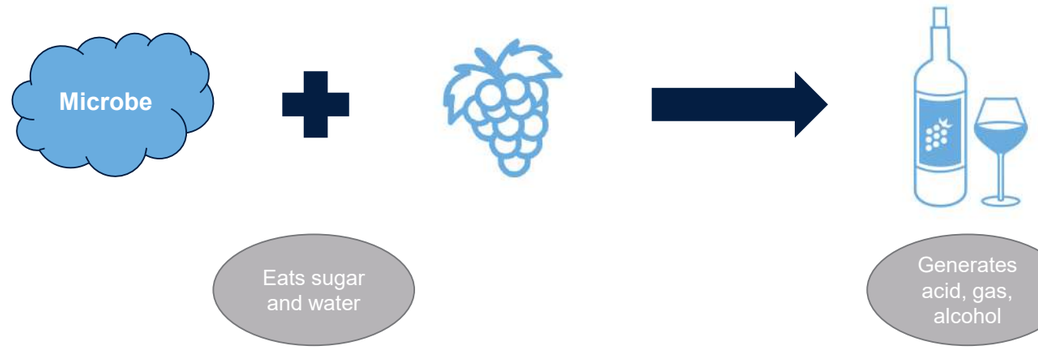
Food ingredients produced using fermentation

Technology

What do cheese, bread, wine, and beer have in common? They are all the product of the thousand-year-old process that is fermentation, which is not only used to preserve food, but also to modify its taste, texture and colour.

Traditionally, fermentation is the process by which a microorganism (microbe) transforms a food or beverage. These microbes can be split into three subcategories: bacteria, yeast, and mould. Fed with sugar and water, these microorganisms generate energy and multiply. In this process, they generate acid, gas or alcohol which are the key drivers of food transformation into bread or beer.

FIG 9: ILLUSTRATION OF TRADITIONAL FERMENTATION PROCESS



*Source: Stifel**

Four main types of traditional fermentation exist:

- Lactic fermentation: lactic acid generated by carbohydrates and lactic ferments. Mostly used for dairy.
- Alcoholic fermentation: sugar is transformed into alcohol (wine, beer) in a no-air environment or into CO2 and energy (in an open environment, production of bread for example).
- Acetic fermentation: the previously created alcohol is put in contact with air to oxide. This is how vinegar is created.
- Propionic fermentation: uses a wide range of substrates (sugar, glycerol, lactic acid…) and is particularly used to create cheese.

FIG 10: SOME OF THE MOST COMMONLY PREPARED FERMENTED FOODS/BEVERAGES WITH THEIR FERMENTATION MICROORGANISMS

Fermented Foods/Beverages	Substrates Used	Microorganisms Involved in Fermentation
Dairy products Curd, Yogurt, Cheese, Yakult, Kefir	Milk and milk casein	Lactobacillus bulgaricus, Lactococcus lactis, L. acidophilus, L. cremoris, L. casei, L. paracasei, L. thermophilus, L. kefiri, L. caucasicus, Penicillium camemberti, P. roqueforti, Acetobacter lovaniensis, Kluyveromyces lactis, Saccharomyces cerevisiae
Vegetable products Kimchi, Tempeh, Natto, Miso, Sauerkraut	Soybean, cabbage, ginger, cucumber, broccoli, radish	Leuconostoc mesenteroides, Aspergillus sp., Rhizopus oligosporus, R. oryzae, L sakei, L plantarum, Thermotoga sp., L. hokkaidonensis, L. rhamnosus, Rhodotorula rubra, Leuconostoc carnosum, Bifidobacterium dentium, Enterococcus faecalis, Weissella confusa, Candida sake
Cereals Bahtura, Ambali, Chilra, Dosa, Kunu-Zaki, Marchu	Wheat, maize, sorghum, millet, rice	L. pantheris, L. plantarum, Penicillium sp., S. cerevisiae, L. mesenteroides, E. faecalis, Trichosporon pullulans, Pediococcus acidilactici, P. cerevisiae, Delbrueckii hansenii, Deb. tamari
Beverages Wine, Beer, Kombucha, Sake	Grapes, rice, cereals	Aspergillus oryzae, Zygosaccharomyces bailii, S. cerevisiae, Acetobacter pasteurianus, Gluconacetobacter, Acetobacter xylinus, Komagataeibacter xylinus
Meat Products Sucuk, Salami, Arjia, Jama, Nham	Meat	L. sakei, L. curvatus, L. plantarum, Leuconostoc carnosum, Leuconostoc gelidium, B. licheniformis, E. faecalis, E. hirae, E. durans, Bacillus subtilis, L. divergens, L. carnis, E. cecorum, B. lentus

Source: Microbial fermentation and its role in quality improvement of fermented foods, Sharma et Al, 2020

It is important to distinguish between solid-state fermentation and submerged fermentation (or liquid-state fermentation) here.

FIG 11: DIFFERENTIATING SOLID STATE AND LIQUID STATE FERMENTATION

	Solid-State Fermentation	Liquid-State (Submerged) Fermentation
Technique	Absence of water, occurs when the microorganism is in contact with a solid substrate	Liquid medium is needed to grow the microorganism. Agitation can be needed to activate the process
Substrate	Solid: grains, wheat, rice	Liquid: molasses, broths
Microorganisms	Bacteria, yeast, filamentous fungi	Bacteria with high moisture content
Advantages	Productivity and Process ++ Cost ++ Energy Intensity ++ Contamination risk ++ Growth -- Purification - Scale-up --	Productivity and Process + Cost + Energy Intensity -- Contamination risk -- Growth ++ Purification + Scale-up -

*Source: Stifel**

b Uses old and new

Fermentation has long been a key component of food ingredient production, with products such as vinegar, soy sauce or kimchi all resulting from a fermentation process. Large ingredients companies also use fermentation to supply their clients with enzymes or high protein ingredients. Use of these processes is growing in popularity, supported by strong underlying trends as highlighted by Kerry Group's Jacques Georis in an interview in 2021.

"Despite being the oldest "biotechnology", fermentation is currently enjoying renewed popularity with the public given increasing awareness of the health benefits that fermented foods offer, their ability to naturally protect food as well as their ability to create a unique taste profile.[…]. Consumers are looking for products offering health benefits and view fermented products as natural, authentic and containing the desired health boosting benefits. […) Consumers are looking for natural products and fermentation is a natural process. […] Finally, consumers are looking for exciting new flavours and are exploring the world through their taste buds in order to seek adventure."

Jacques Georis, Global Fermentation Science Director for Kerry Research and Development and Applied Health and Nutrition

FIG 12: SOME ESSENTIAL COMMERCIAL ENZYMES USED IN FERMENTED FOODS/BEVERAGES.

Substrates	Enzymes	Microbial Source	Enzymatic Action/Process
Dairy	Protease Catalase Lactase	A. niger, A. orzyae and B. subtilis S. boydii and Bacillus sp. B. subtilis	Cheese production Removing H2O2 Lactose-free milk
Cereal	Amylase Protease Pentosanase Glucose oxidase Phytase Pullulanase Xylanase Lipases B-glucanase A-acetolactate-decarboxylase Amyloglucosidase Cellulase Pectinase	B. licheniformis and B. subtilis A. niger Trichoderma sp. P. notatum A. niger B. acidopullulyticus A. oryzae and B. subtilis Aspergillus niger B. subtilis, A. niger and P. funiculosum B. subtilis A. niger and A. flavus T. longibrachiatum A. niger	Malting, mashing, liquefaction, and production of flavor esters
Beverages	Glucose oxidase Tannase	P. notatum A. niger	Clarification of juices Removing O2 Hydrolysis of esters
Meat	Papain Protease	S. aureus T. longibrachiatum, A. niger, A. oryzae and B. subtilis	Tenderization of meat

Source: Microbial fermentation and its role in quality improvement of fermented foods, Sharma et Al, 2020

Recently, renewed interest in the large scope of uses of fermentation has emerged, prompting ingredients companies to look at applications outside of their primary focus in food & beverage. New applications include food preservation, waste treatment or even plastic recycling.

Case Study: Novozymes

Novozymes is a Danish biotech company and ingredients company founded in 2000. It is specialised in enzymes production across various sectors (agriculture, food and beverage, energy).

Creating a leader in Enzymes Production

Novozymes has been building a leading position in enzymes since the 1930s and is also active in insulin production. It now accounts for 50% of the world's enzymes production. The group has also developed enzyme applications for household products (detergents), food products (proteins) and bioenergy development. The company's mission has evolved towards bringing biology to industry and consumers to make products more sustainable.

Merger with Chr Hansen to expand the lead in biosolutions

In December 2022, Novozymes announced its intention to merge with Chr Hansen to create a leader in biosolutions. The combined company will be able to address megatrends and capture more opportunities in a market expected to triple by 2040. A key pillar of the strategy is to share and expand Chr Hansen's microbial expertise (over 40K strains collection) into Novozymes' biosolutions model and target more applications.

Exploring opportunities through partnerships: the Carbios example

Novozymes and Carbios have been partners in PET recycling and PLA biodegradation since 2019, but the partnership took on a new scale in 2023 when the two companies entered an exclusivity agreement. Novozymes will supply industrial quantities of Carbios' proprietary PET recycling enzymes enabling the recycling of over 50Ktons of PET per year. Beyond Carbios, Novozymes is also partnering with Givaudan, Univar, Fibenol and Azelis in the development of sustainable solutions.

Case Study: Bonumose

Bonumose is a US-based company founded in 2016 which aims to make healthy sugar alternatives affordable for the mass market through its enzymatic production process of tagatose, allulose and others. The company has raised more than $50m to date.

We had a conversation with Ed Rogers, Co-founder & CEO.

Tagatose production at scale

A breakthrough enzymatic bioprocess enables Bonumose to convert maltodextrin into tagatose with twice as high conversion rate as the traditional glucose-to-fructose conversion (85% vs 42% average) and with a less processed feedstock. Purification to >99% pure, crystallized tagatose is relatively simple because the purity is already so high after the enzymatic conversion. Bonumose's process has over 50 patents globally. The irreversible enzymatic conversion process enables Bonumose to use the enzymes continuously, 24/24h making the process highly efficient. This enzymatic conversion process can be replicated to create allulose and other sugar. Tagatose currently is approved in multiple countries, including the EU, but the European Commission's technical specification for tagatose must be updated to reflect the plant-based, starch feedstock method used by Bonumose.

Drop-in sugar replacement

Tagatose is a rare monosaccharide discovered 25+ years ago. Tagatose is recognized in the U.S. as having 1.5 kcal/gram, which is 62% lower than sucrose. Tagatose has a taste, sweetness and functional profile with great similarity to sucrose. With obesity becoming a global challenge, a growing number of governments are implementing sugar tax, with the UK being a key leader here with its HFSS* plan. Around 54 countries have now established some kind of sugar tax to encourage sugar reduction in soft drinks and processed foods. Moreover, WHO reported recently that aspartame, a common sugar replacer could have negative impact on health, generating more cancer. Strategic collaboration with key players such as Hershey and American Sugar Refining is a testimony of the interest and need for scalable tagatose production.

Wider set of opportunities

Beyond being a great sugar replacer, tagatose also comes with several health benefits: acts as a prebiotic and is treated as soluble fibre by the body, is good for dental health, helps lower blood glucose levels, and may be useful to treat pets parasitic infections, among other benefits. This creates an extensive set of opportunities to explore and potential partnership to build. Symrise's partnership is a case in point, helping the company in several areas of collaboration.

Labelling challenge

Although tagatose is not perceived as a GMO and therefore broadly approved, the labelling is a key issue to its widespread adoption. Indeed, many countries consider all monosaccharides to be labelled as "added sugar," and tagatose is a monosaccharide.. This could be misleading for consumers. Change here will be key to accelerate tagatose's development.

*High Fat Salt or Sugar is a regulation restricting promotions and placement in retail stores of certain foods and drinks high in fat, salt or sugar or deemed as less healthy.

New companies are working on extending the fermentation process to create new ingredients that offer improved protein and fibre profiles compared to their traditional equivalent. They engineer microorganisms so that, when in contact with feedstock (sugar, food processing by-products) they can generate an improved ingredient (microorganism) that can then be added to food recipes.

Case Study: MOA Foodtech

MOA Foodtech is a Spanish company founded in 2020 which has developed an AI driven platform that transforms waste and by-products of the agri-food industry into a high value ingredient. The company has raised EUR1.5m since inception.

We had a conversation with Bosco Emparanza Garcia, Co-founder & CEO.

End-to-end platform powered by AI

MOA Foodtech sits at the intersection of biomass and precision fermentation, using selection of microbes. The company has a large library of over 300 microbes registered in its Albatros platform that helps find the perfect match between microbes, feedstock, and targeted utilisation. MOA Foodtech has already developed two of its own products, MOA Protein and MOA Gelling which offer improved nutritional profiles (50% protein, 30 fibre, omega, group B vitamins and all the essential amino acids). A key of MOA Foodtech's model and perception of the future is the willingness to use food by-products and create value from them, therefore reducing food waste in our economies.

Supporting large groups, a key to development

Thanks to the wide range of possibilities offered by its platform, MOA Foodtech has already been able to secure several partnerships with large food manufacturers and ingredients providers. For example, it works with Barilla to develop projects, unveil the potential of pasta production by products through fermentation, and value waste. The partnership is demonstrating great conversion rates at this point.

Never-ending set of possibilities

MOA Foodtech's AI system, Albatros, consist of a predictive frame and an artificial intelligence frame. The key point of Albatros are genome-scale metabolic models. These models comprise the whole metabolism of said microorganism, granting MOA to explore microbial behavior in fermentation processes. Besides, MOA is able to compute not only a pure culture of microorganisms, but microbial consortia, which opens a whole new set of possibilities regarding fermentation processes.

Albatros allow to adapt MOAs fermentation process to whatever by-product can be used in the moment, without having to go through innumerable experiments in the laboratory. Albatros has been an internal tool, but the tool's potential will give the opportunity to other fermentation companies and startups to optimise their fermentation processes in terms of costs and sustainability impact..

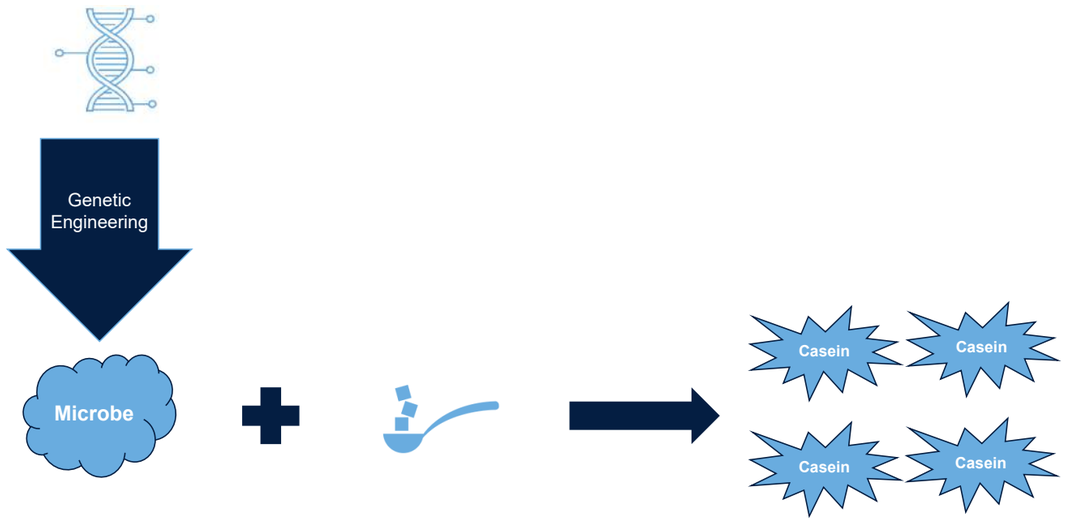
Going a step further with precision fermentation

Technology

What if were possible to improve the microbes used in fermentation in order to change the results of fermentation and create a whole new product? This is the aim of precision fermentation: .using genetic engineering of microorganisms used in the fermentation process to change the result of fermentation and create new proteins from scratch.

Precision fermentation has been used in the pharmaceuticals industry and to produce certain ingredients. It is now increasingly being used to replace animal proteins such as casein and egg protein, or to create food grade pigments. In food, precision fermentation is particularly useful in dairy or meat alternatives, enabling better taste, texture and nutritional properties than traditional products.

FIG 13: ILLUSTRATION OF THE PRECISION FERMENTATION PROCESS

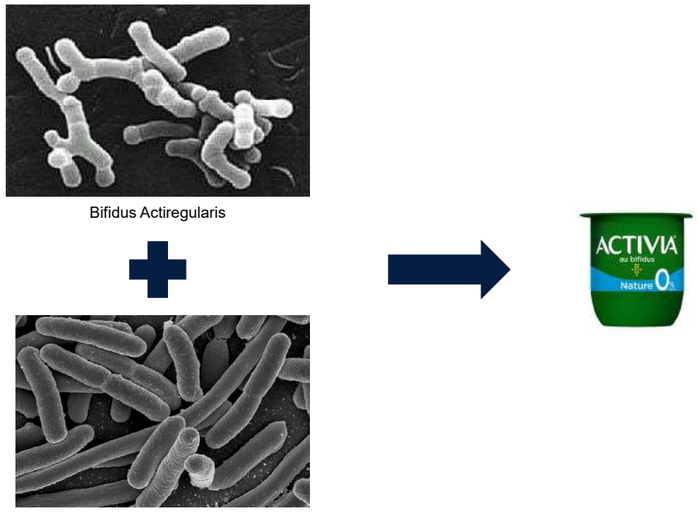


*Source: Stifel**

Precision fermentation innovation in dairy

Dairy is a prime application of fermentation: yogurts and cheeses are all made through fermentation. The industry has been working on the selection and optimisation of microorganisms for a while now. For example, yogurt contains two main bacteria: *lactobacillus bulgaricus* and streptococcus thermophilus which can then be complemented with other bacteria. For example, Danone's Activia yogurt contains over four million *Bifidus ActiRegularis* which make the yogurts high in probiotics and good for gut health. Recent developments in high protein yogurts are a great example of what fermentation enables dairy companies to do.

FIG 14: MICROORGANISMS USED IN THE ACTIVIA PRODUCTION PROCESS.



*Source: Stifel**

Milk contains several proteins that are used in the production of fermented dairy, such as lactoferrin and casein in whey or cheese production.

Lactoferrin (50-60g/litre of milk) is a dairy protein that has immunity properties, for new-borns and enables iron fixation in the human body.

Casein (15 to 50g/litre of milk) is a dairy protein that has slow assimilation for the organism and is useful in sport nutrition, supporting muscle building, or weight loss. Casein is a key component of whey powders for which demand has surged in the past few years.

Growing demand implied by renewed interest for an active lifestyle and sports nutrition has led a new wave of companies to work on reproducing these proteins without cows, through precision fermentation. This enables the use of milk resources in a more reasonable way, and to focus on high-end use cases such as cheese.

This part of the market is particularly attractive as the dairy protein market accounts for roughly 2.5% of the global ingredients market and is expected to grow at 13.8% over the 2021-2028 period, outpacing the overall ingredients market (mid-single digit growth).

Case Study: Standing Ovation

Standing Ovation is a French precision fermentation company founded in 2020 and focused on producing cow-free casein for the dairy industry. The company has raised EUR12m since inception.

We had a conversation with Frédéric Pâques, Co-founder and CEO.

Focus on Casein production
Standing Ovation was founded in 2020 in a context of growing pressure on animal proteins that is set to have a particularly harsh impact on dairy by 2030. The unsatisfactory taste of vegan cheeses convinced the company of the need for new, innovative solutions.

Casein is an essential protein for producing many dairy products. Its absence in plant-based alternatives is one of the reasons for the huge difference in taste and texture, and difficult comparison with dairy. It is also one of the many difficult dairy proteins to reproduce using precision fermentation, and with most companies focusing on whey production, there is a white space for Standing Ovation.

Supported by BEL partnership
Standing Ovation is working closely with BEL, one of the leading dairy groups in France and Europe to find applications in dairy for the four types of casein they have been developing. The goal is to incorporate Standing- Ovation's caseins in BEL's new cheese products. The company intends to remain focused on providing ingredients and thus not move into the B2C channel. It aims to develop attractive products that can be made by mixing its products in various proportions with plant-based or mineral products.

Food sovereignty at stake
Standing Ovation's ingredients are essential in a world where resources are increasingly limited and at risk of climate change but suffer from a long regulatory timeline in Europe: it takes half the time to obtain regulatory approval in the US than in Europe.

Case Study: Bon Vivant

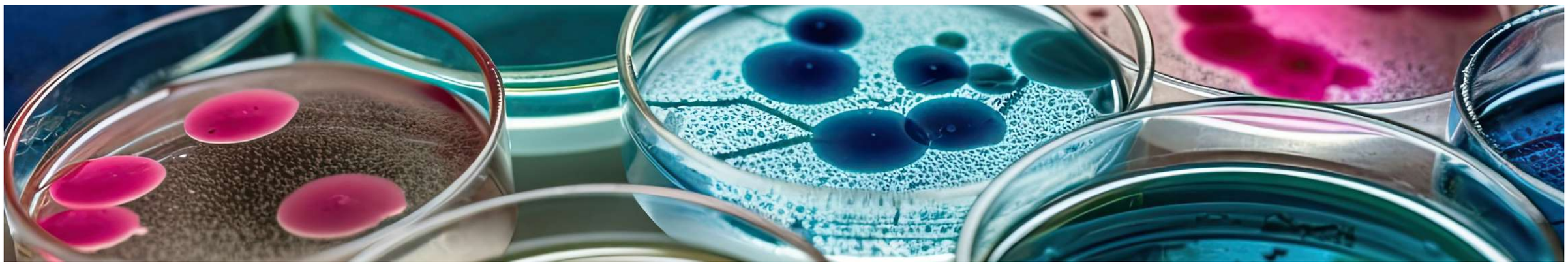
Bon Vivant is a French precision fermentation and cultivated protein company working on dairy proteins. The company was founded in 2021. Bon Vivant has raised EUR4m (+ new funding round not yet disclosed) since inception.

We had a conversation with Stéphane MacMillan, Co-founder & CEO.

Tech combination for the greater good
Bon Vivant is working on two technologies simultaneously. On one hand, the company is reproducing dairy proteins that participate in taste, texture, and nutritional attributes of various dairy products using precision fermentation. On the other hand, it uses stem cell technology to reproduce fat and complex dairy proteins such as lactoferrin which plays an essential role in iron concentration. Both technologies can be used to improve the nutritional profile of dairy products and make them more functional.

Disrupting ingredients
Bon Vivant's view is that there are fewer regulatory and consumer barriers to the consumption of precision fermentation or cell-based dairy ingredients than cultivated meat. This is why the company has positioned itself as a disruptor in the ingredients industry, with its products also accounting for a small share of the manufacturer's costs. However, partnerships with large ingredients or food manufacturing companies will become necessary to enable access to further CAPEX and pursue the development of these innovations.

Help refocusing and revaluing the agricultural Industry
Ultimately, as this CAPEX is unlocked, Bon Vivant's ingredients will become cheaper and faster to produce (slightly over 100h compared to several weeks or months from cows). This should help refocus the use of cattle on high value applications such as AOP cheeses as well as having positive side effects on the overall agricultural industry and farmers' earnings.



Improving plant-based proteins with precision fermentation

Taste is the number one reason why consumers do not try plant-based proteins again and the key headwind for widescale acceptance and increased penetration. Perfect replication of taste and texture of traditional proteins remains a key challenge for plant-based alternatives and fermentation offers great solutions here:

- **The taste issue:** by using specific microbes with the ability to alter the taste and texture of traditional alternative proteins, precision fermentation fosters greater parity and enables a wider penetration of these products.
- **Fat and nutritional issue:** ingredients lists can also be shortened with precision fermentation, replacing some of the flavouring additives while improving fibre and protein content compared with products currently available. This contributes to cleaner recipes and a better nutritional profile for plant-based proteins.

Case Study: Väcka

Väcka is a Spanish plant-based dairy alternative, which produces cheese from melon seeds, precise fermentation. The company was founded in 2015 and has raised EUR1.6m since inception.

We had a conversation with Maxime Boniface, Co-founder and CTO.

Circularity based model

Although Väcka's product development started with nut-based milk, it gradually shifted to melon seeds, which offer a better taste and texture parity with dairy products. With Spain being the eighth largest melon producer globally (and first European) and melon being partly sold through cut portions, this enables Väcka to develop a circular business model.

Traditional fermentation to accelerate the road-to-market.

Väcka's founders are seasoned biologists, specialised in microorganisms and working with CNTA, a Spanish institute specialised in fermentation, with a large bank of microbes. The company has discovered four types of microorganisms that enable good replication of dairy products and continues to work on identifying microbes that could unveil more flavours.

This model, which is not engineering microorganisms, enables Väcka to be ready for commercialisation faster than European precision fermentation firms (which the company estimates will not be ready for three/four years), together with cheaper production costs.

Wider retailer acceptance will be key to boost penetration

Last year, Väcka won Carrefour's plant-based challenge, which provided it a retailing space. The company started selling in Carrefour Spain in August, and Väcka's products are now available in 90+ stores around the country.

Maxime Boniface, Väcka's cofounder, considers that taste is no longer an issue, but price is. In this context, the integration of Väcka's products on retailers' shelves as well as increased foodservice presence will enable further consumer penetration and volumes, leading to economies of scale.

Case Study: Paleo

Paleo is a Belgian company founded in 2020. It researches and develops new functional ingredients to improve plant-based meat and fish alternatives. Through precision fermentation, Paleo produces specific meat and fish proteins which are 100% bio-identical to animal proteins and 100% GMO-free. The company has raised EUR14m since inception.

We had a conversation with Hermes Sanctorum, Co-founder & CEO.

From chicken to mammoth meat taste

Paleo's precision fermentation technology enables them to create a portfolio of ingredients for plant-based food that brings the taste and typical characteristics of meat or fish. The choice between species is made on different functionalities and how they can complement each other from an aromatic profile, colour, and stability perspective. Paleo currently develops a portfolio of 6 animal proteins of different species, even including mammoth. Reintroducing mammoth proteins back into the human diet was set out as a challenge and a showcase of both Paleo's technology and mission. By recreating proteins from a long extinct animal, Paleo wants to demonstrate that their technological platform can create any type of ingredient, and that they don't need animals to do so. Because their technology is based on extracellular pathways, Paleo is not considered as a GMO and although it is still considered as a Novel Food, it does not have to follow the GMO track.

Three development tracks

The first development is technological, straightforward. The second development will be commercial. Here again, the company is upgrading its infrastructure to be able to generate large scale production and reach the next development stage, which will enable it to attract further investor interest. The last development track is regulatory, which remains a typical challenge as all countries have different regulations one must adapt to.

FOCUS

Operating costs will impact long term success of innovations

Beyond equipment cost, fermentation technologies generate different operating expenses that impact the path to profitability and price parity. In the table below, we detail the main cost items and their relative importance in the total cost of production.

FIG 15: FERMENTATION EQUIPMENT TYPES

	Fermentation	Mycoprotein	Cultivated Proteins
Feedstock	+ Sugar from various sources. Ability to shift sugar sources will be key to win on that market	= Mycelium only requires warmth, humidity, CO2 to proliferate.	+++ Growth media is a key cost here, ranging from USD0.25 to UD377/liter. Stem cells are another important cost, that will progressively be optimized and internalized.
Wage	=/+ Scientists and microbiologists (USD50-75K/annum).	+ Scientists and microbiologists (USD50-75K/annum).	++ Scientists and microbiologists with extensive knowledge in a novel field (USD50-300K/annum).
R&D	++ Depends on the level of novelty and innovation. Precision and microbial fermentation will be more costly in R&D than traditional fermentation.	++ A lot remains to discover in the mycelium field: strains, cultivation, uses. Companies looking for new strains or applications will experience higher R&D costs.	++ Cell lines, growth media optimization, development of novel technologies and processes require extensive R&D efforts.
Energy	=/+ In line with industrial average, growing with the size and intensity of bioreactors used and heat required for fermentation process.		
Process	= In line with existent fermentation processes, lots of knowledge in the space making it easier to scale.	=/+ Fairly easy production process but scaling it could generate increase costs.	+ Process isn't the core knowledge area of start-ups and requires a specific set of employees. Scaling might lead to important changes which could be costly.

=/+/++/+++ represent the magnitude of costs

Source: Stifel Estimates, Company Reports*

Although fermentation and mycoprotein technologies appear to have the lowest operating costs, we expect that as cultivated proteins scale up, more developments will be made on cell lines and growth media, leaving room for cost optimisation and reduction which will support the road to parity.

Moreover, higher operating costs in the cultivated proteins space should be offset by the premium price consumers are prepared to pay for these products.

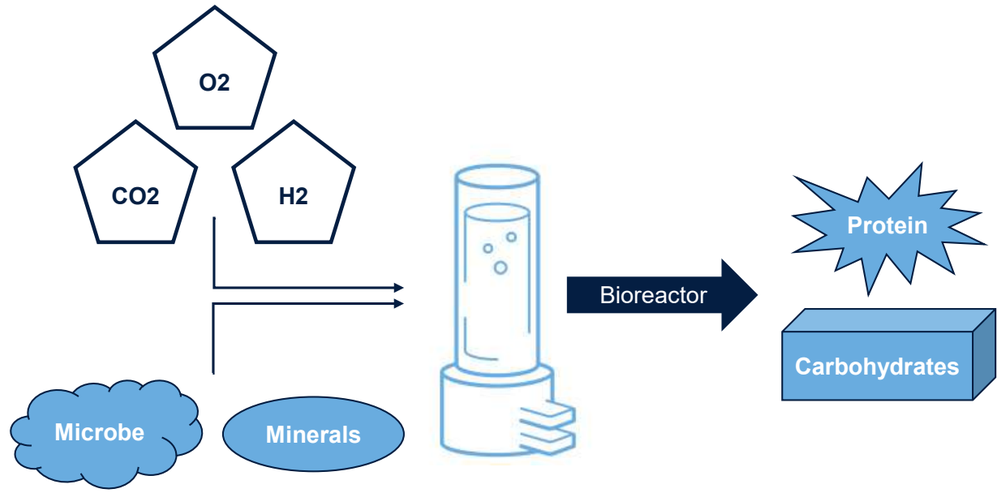
Never-ending innovation: microbial fermentation

Technology and use

Research is exploring new uses of fermentation. Applications for space and providing safe and nutritious food for astronauts has recently been a key area of interest.

Gas or microbial fermentation is a solution. It replaces the feedstock (sugar) component of traditional fermentation with a combination of hydrogen, oxygen and carbon dioxide, minerals such as ammonia, together with microorganisms in a bioreactor to generate protein, carbohydrates, or other molecules.

FIG 16: ILLUSTRATION OF THE GAS FERMENTATION PROCESS



*Source: Stifel**

Case Study: Solar Foods

Solar Foods is a Finnish company using microbial fermentation to produce Solein, a high protein and fibre ingredient made from air. The company has raised EUR105m since inception in 2017.

We had a conversation with Pasi Vainikka, CEO.

Born with space
Solar Foods offers Solein, a protein and fibre-rich ingredient made from the oxidation of hydrogen and carbon dioxide, creating a cell biomass that is then transformed into an ingredient. The production process from Solein includes a growth media, which we call the minerals above, meaning it is an enhanced water solution to feed microbes with.

Large set of advantages
Solein's advantage is that it's theoretically easy to scale, has limited off taste and texture issues and fits really well into most recipes, especially as an egg replacer. It also uses no space beyond the bioreactor as well as limited energy, together with limited emissions.

Circular process
Solar Foods was born from a hydrogen facility in the EU (IPCEI Project) and has therefore used renewable energy sources from the beginning, with its own electrolysis on plant. A key vision for the company as it moves into building its production facility is to be ramping up production from 2024.

Fostering a more circular world through fermentation

Fermentation tanks are full of leftovers (from the beer production process for example). Although this is not directly a fermentation process, we found it interesting how some companies are working on using these leftovers to create new, circular ingredients that can replace egg white or act as foaming agents in the food production process.

We believe these products also benefit from the fact that they are derived from a food fermentation process which prevents them from falling under the Novel Food regulation.

Case Study: Revyve

Revyve (formerly FUMI Ingredients) produces ingredients using spent yeast from breweries. The company was founded in the Netherlands in 2019 and has raised EUR8.5m since inception.

We had a conversation with Corjan Van den Berg, Co-founder.

From beer to egg
Revyve collects spent yeast from beer tanks, breaks down the cells, purifies and dries them to get a product that acts as a vegan egg white replacement. Over time, we can imagine this process being replicated into other sources of biomass, such as precision fermentation, baker's yeast, and bio-ethanol production, leading to the creation of new ingredients with additional properties.

Outsmarting the competition
Reyve offers an ingredient that is cost competitive with egg (for which prices have surged from EUR2/kg to EUR25/kg recently) while offering enhanced foaming properties and cleaner label.

Revyve's production process is also cost efficient, as uses spent yeast and avoids some of the bioengineering aspects that precision fermentation companies have to deal with.

It's all about scale
Revyve has started producing ingredients and expects to produce 100 tons of its products next year (from 400kg/batch at the moment). Manufacturing capabilities will be increased when Revyve moves from co-manufacturing to owning its own plant, supported by some important strategic partners.

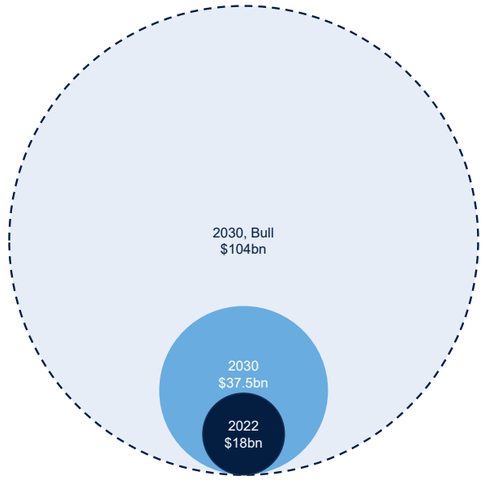
Addressable market

Should production capacity align, Stifel* estimates the total addressable market opportunity for fermentation in 2030 to reach up to USD104bn by 2030.

This is based on the consideration of the potential penetration across the two main markets for fermentation products: food ingredients and protein replacement.

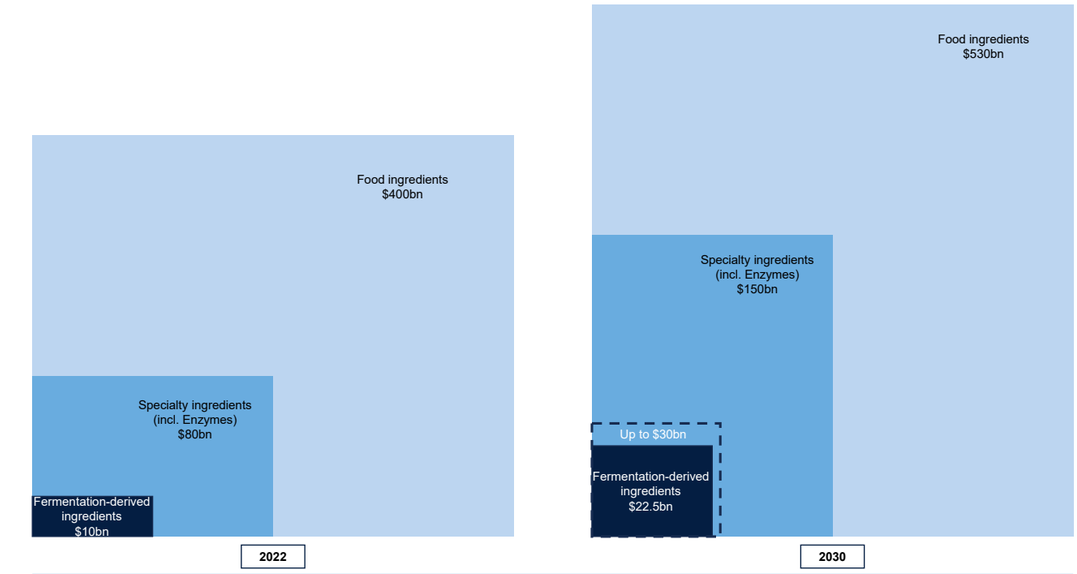
For food ingredients, the overall market (including all types of ingredients: taste, texture, sweeteners) should grow by about 4% per annum over the 2022-2030 period, reaching USD530bn. Within this market, specialty ingredients (targeting specific benefits when added to the recipe) should outperform and growth a 9% CAGR to reach USD150bn. Current penetration of fermentation derived ingredients is estimated to be around 12.5% and has the potential to reach 15-20% by 2030, therefore representing a market of USD22.5 to USD30bn.

FIG 17: FERMENTATION TOTAL ADDRESSABLE MARKET



Source: Stifel, Statista*

FIG 18: FOOD INGREDIENTS MARKET FORECAST



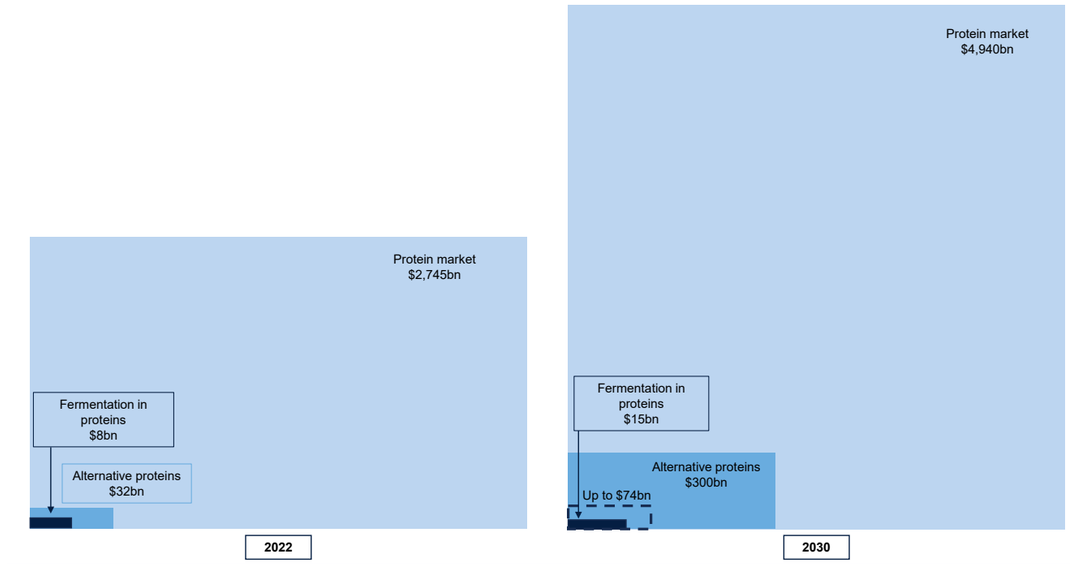
Source: Stifel, Company Reports*

Protein is defined as the combination of meat, seafood, and dairy. The market is split into two sub opportunities:

- The use of fermentation to improve the taste and texture of plant-based protein, as in the case of Väcka, estimated to represent a USD1bn market in 2022 and USD2-16bn market opportunity by 2030.
- The use of fermentation in hybrid products which combine plant-based alternatives with fermentation derived ingredients to improve the taste, texture, and nutritional profile. To assess the potential market, we assumed this would be a part of the processed protein category and increased penetration. Although still limited, we expect this to represent a USD12-58bn opportunity by 2030, from USD7bn in 2022.

Therefore, we estimate the addressable market for fermentation in the protein space to be USD15-74bn by 2030.

FIG 19: PROTEIN MARKET FORECAST



Source: Stifel, Company Reports*

FIG 20: GROWTH FORECASTS FOR PROTEIN MARKET SUBSEGMENTS

	2022	2030	CAGR 2022-2030
Meat	$1,200bn	$2,300bn	8.5%
o/w Alternatives	$10.1bn	$23-115bn	11-36%
Alternatives Penetration	0.8%	1-5%	
Dairy & Eggs	$1,000bn	$1,700bn	7%
o/w Alternatives	$21.4bn	$86-172bn	19-30%
Alternatives Penetration	2.1%	5-10%	
Seafood	$545bn	$940bn	7%
o/w Alternatives	-	$1-5bn	-
Alternatives Penetration	0%	0.1-0.5%	
Total Protein Market	$2,745bn	**$4,940bn**	7.6%
Total Alternative Protein Market	$32bn	$110-292bn	17-32%

Source: Stifel, Company Reports*

FIG 21: PROCESSED FOODS MARKET FORECASTS

	Meat	Dairy	Seafood
Proportion of Processed Foods	30%	70%	30%
COGS as a % of Processed Foods Revenue	77%	78%	40%
Fermentation Penetration of Processed Foods Ingredients (2030)	0.5-2%	1-5%	0.25-0.5%
2020e Revenue	$1.4bn	$5.5bn	$0.2bn
2030e Revenue	$2.7-10.7bn	$9.4-46.9bn	$0.3-0.6bn

Source: Stifel, Company Reports*

Concerns for further developments

Fermentation has huge potential in the food space, with many innovations to be adopted in the short to medium term. A few hurdles remain:

- **Regulation**

The key questions are whether the ingredients produced fall into the Novel Food or GMO categories. If they are neither, the approval process is relatively straightforward. For products stemming from precision fermentation there is a risk that the genetically modified nature of the microorganisms used might lead to the product not being approved.

- **Cost**

Despite being needed, newly developed fermentation solutions require extensive R&D efforts to optimise microorganisms. Reducing the total cost of development, as well as increasing capacity to shift between feedstocks will be needed to reach cost parity with traditional ingredients.

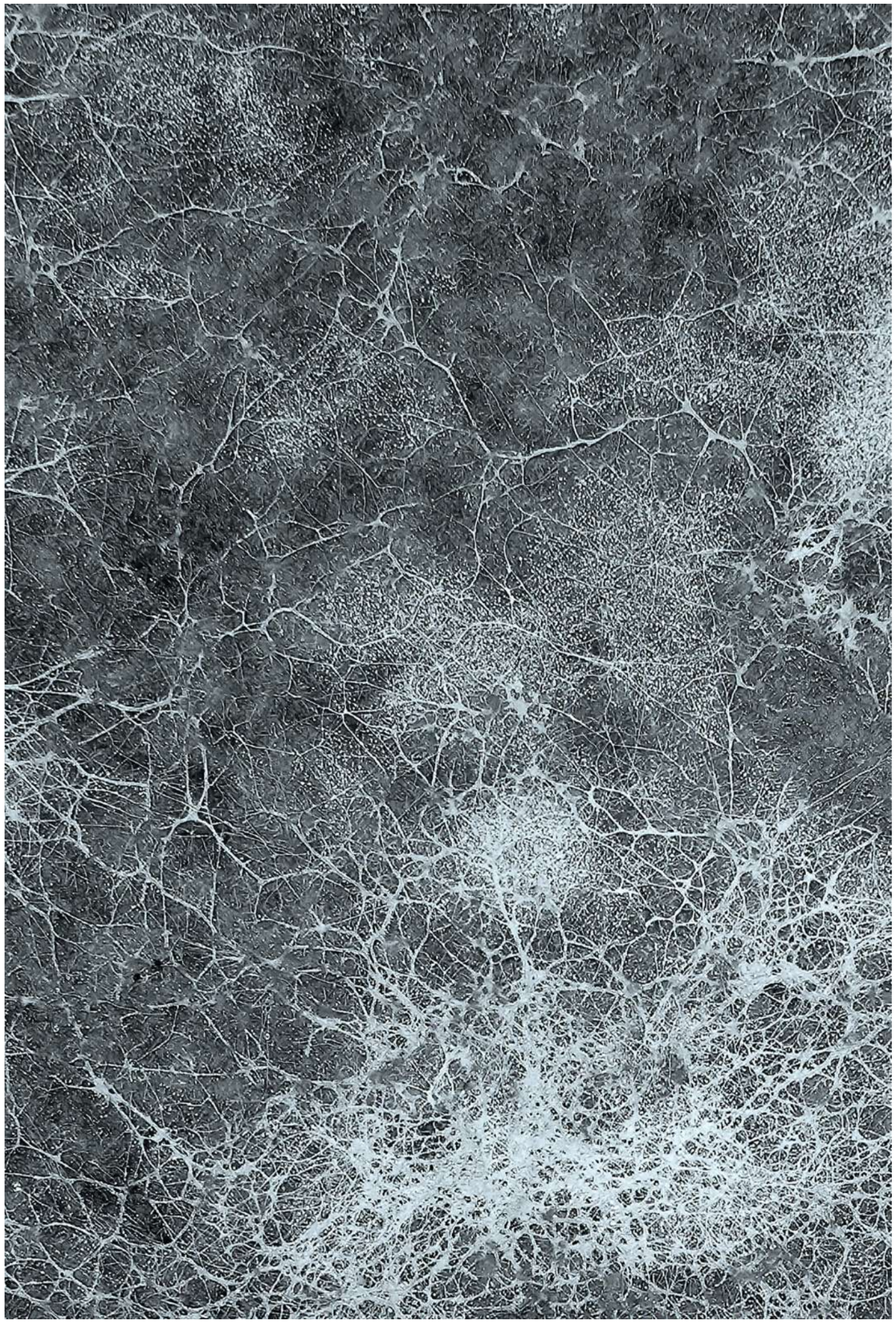
- **Consumer attitudes**

Ingredients produced using fermentation have existed for a while and are particularly well accepted by consumers. Because not directly an end-product, penetration will be easier and quicker.

The development of plant-based alternatives will be supportive of fermentation-derived ingredients that improve the taste and texture of these products and are supported by Gen Z's willingness to try and adopt more sustainable food habits.

Outlook

Demand for innovative ingredients has never been so high, creating a white space for fermented ingredients to develop strongly in the coming years. Price parity will be key for increased penetration, but we are very confident in the outlook for these products.



MYCOPROTEIN:
WORLD OF ITS OWN

SECTION 4

MYCOPROTEIN: WORLD OF ITS OWN

FIG 22:OVERVIEW OF THE MYCOPROTEIN MARKET

Source: Stifel, Mycostories*

Technology

Biomass fermentation

Biomass fermentation generates more microorganisms by the consumption of sugar and water, instead of altering the taste, texture, or colour of a specific food product. This is particularly useful in the context of creating large portions of a product from a limited amount.

FIG 23: ILLUSTRATION OF BIOMASS FERMENTATION PROCESS

*Source: Stifel**

Mycoprotein derives from biomass fermentation, using fungi to produce a large quantity of products.

Fungi is a living organism that forms its own branch, with mushrooms being a type of fungi (their fruiting body). Mycoprotein derives from the fermentation of filamentous fungi (Fusarium venenatum) to generate great meat analogues.

Why use mycoprotein

Mycoprotein has several advantages:

- Due to its natural nature (fungi strains having been known for a while) the regulatory hurdle is lower than for other fermentation derived processes, which makes it easier for companies to establish themselves in this market.
- It is very versatile: fungi can be scaffolded and textured to replicate the texture of a beef patty and therefore be sold as a product of its own or used as an ingredient for its great foaming capabilities as well as high protein and fibre qualities.
- Consumers are accustomed to mushrooms, and therefore acceptance of a derivative product should be easier than for other, new products.
- Mycoprotein offers a great nutritional profile compared to meat analogues, thanks to its high protein and fibre contents for a low calorific content. The risk of allergies is also lower compared to other protein sources.

FIG 24: COMPARISON OF NUTRITIONAL PROPERTIES: QUORN, BEEF, CHICKEN

Per 100g	Mycoprotein (Quorn)	Beef Patty	Chicken Breast
Energy (Kcals)	85	330	160
Proteins (g)	11	26.5	28.5
Fat (g)	2.9	24.4	5.2
Fiber (g)	6	0.7	0.9
Bioavailability and Essential Amino Acids	0.996	0.92	1

Source: Stifel Estimates, Company Reports*

- Less than 2% of the total available fungi strains are known and used at this point. Technological progress will enable the discovery of more strains, and related applications thereby creating an infinite set of opportunities to seize.

Mycoprotein is a great opportunity to solve the growing protein gap at scale and low cost.

The technology already benefits from Quorn's establishment in the space. Founded in 1985, Marlow Foods is now commercialising Quorn's mycoprotein in over 17 countries, creating an attractive precedent for start-ups considering fungi applications to food.

Moreover, Quorn is going beyond its role of industry leader, by supporting innovators in the field in their developments. The establishment of Marlow Ingredients from 2023 is a strong signal of the company's enthusiasm about its market and the opportunities there, as well as an encouragement for others to continue investing in the sector.

FOCUS

Leader's View: Quorn

Marlow Foods is the leading mycoprotein company globally, selling Quorn products since 1985. Quorn's products are now available in 16 countries, and Quorn announced the launch of Marlow Foods Ingredients in 2023, to help unveil the full potential of mycelium by supplying it as an ingredient to global food players.

We had a conversation with Tom Lindley, Head of Strategy and Marketing for Marlow Ingredients.

From consumers to producers

Quorn is now present across three segments. Its initial business, B2C mycoprotein products are made into over 100 SKUs available in 16 countries now across both chilled and frozen products. The second arm of Quorn is Quorn Foodservice, which partners with large quick service restaurant brands to make mycoprotein available (with KFC in Europe for example). The third arm officially started in April 2023 with the launch of Marlow Ingredients, a B2B mycoprotein ingredients provider.

Tell me more… Marlow Ingredients?

Quorn decided to move into supplying its products to other food manufacturers, and therefore have a much broader impact on making mycoprotein widely available while tackling climate change, which led to the establishment of Marlow Ingredients announced in April 2023. The mycoprotein market is still underpenetrated and offers a wide range of opportunities, and making Quorn's ingredients available to large food manufactures will help to make mycoprotein more popular globally.

A great ingredient to have

Marlow Ingredients also come with enhanced nutritional values: low saturated fat, cholesterol and high fibre making it highly digestible, as well as low sugar. This makes Quorn's products perfectly aligned with growing consumer attention to health and wellness and increasing regulations to limit fat, sugar and salt intake (such as HFSS in the UK). Better health claims concerning mycoprotein will also be key to further developments.

Fantastic innovation underway

Quorn nevertheless appreciates competition in the fungi space, with many players trying different strains leading to different properties and benefits. Acting as an industry will be key to create safe, high quality mycoproteins and more companies working in the field means faster consumer access to products, which will be beneficial. The market is wide enough for cannibalisation not to happen in the short term. Quorn's success in the market is also helpful for the ecosystem, in obtaining regulatory approval a bit faster.

Applications

Meat analogues (textured and untextured) were Quorn's original application which has been developed into other formats since hen.

Case Study: Mushlabs

Mushlabs is a German company using fungi to create a new generation of proteins. The company was founded in 2018 and has raised EUR20m since inception.

We had a conversation with Cathy Hutz, Co-founder & VP of Product.

Fibre-rich European alternative protein

Mushlab's protein puts together by-products from the food and agricultural industries, and a mycelium that uniquely replicates the taste (umami) of meat, with increased fibre content. The key difference with Quorn resides in the mushrooms used in the process which are close to supermarket mushrooms instead of mould. Beyond being very circular, with limited emissions, Mushlabs' process is also faster than most meat or vegan protein production processes.

Scalable process

Compared to precision fermentation or cell-based proteins, mushrooms require no high-end fermenters and are therefore easy to scale using existing capacities. Together with the use of food by-products as raw materials, this makes Mushlabs' concept easy to replicate around the world, thereby saving emissions generated by transportation of the products.

On-shelf availability

Beyond pricing, making the product more available and visible on the shelf will be key. Foodservice has a great role to play, as out-of-home consumption is peaking again and chefs have a great way to enter consumer minds. At retailers, the products' positioning is still uncertain, but Mushlabs expects this new food category to be placed somewhere between alternative proteins and meat, that would make consumers understand the parity in taste and texture with traditional meat, and progressively encourage them to shift.

Pricing advantage

From a pricing standpoint, fungi are more affordable than most solutions. Mushlabs is particularly vocal about the need to align tax incentives across proteins to foster cost parity and accelerate adoption of mycoprotein.

Case Study: Kinoko Tech

Kinoko Tech is an Israeli company founded in 2019 working on providing mycoprotein to private labels. The company has raised EUR1.3m since inception.

We had a conversation with Jasmin Ravid, Co-founder & CEO.

Solid State Fermentation: key differentiation aspect

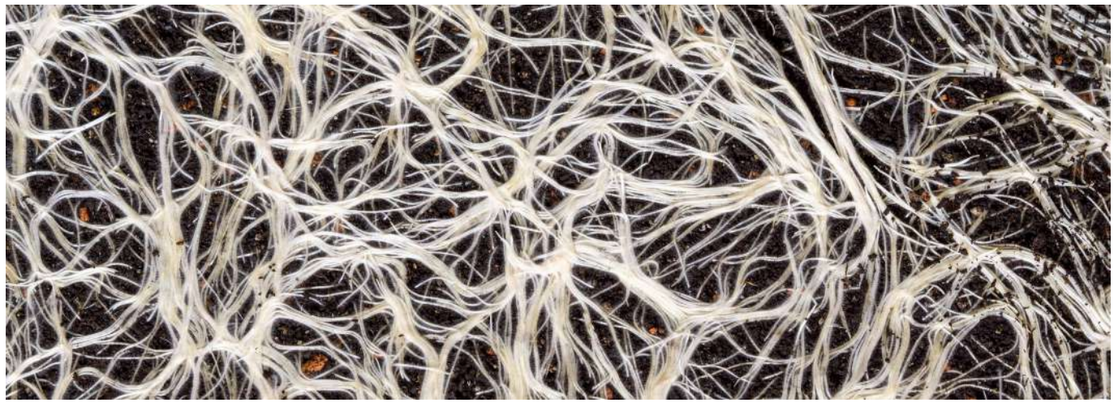
Kinoko Tech uses a solid-state fermentation process which it considers helps offset the downside of liquid-state fermentation. Kinoko Tech considers that solid-state fermentation offers more differentiation (less know-how there) and is more scalable and versatile.

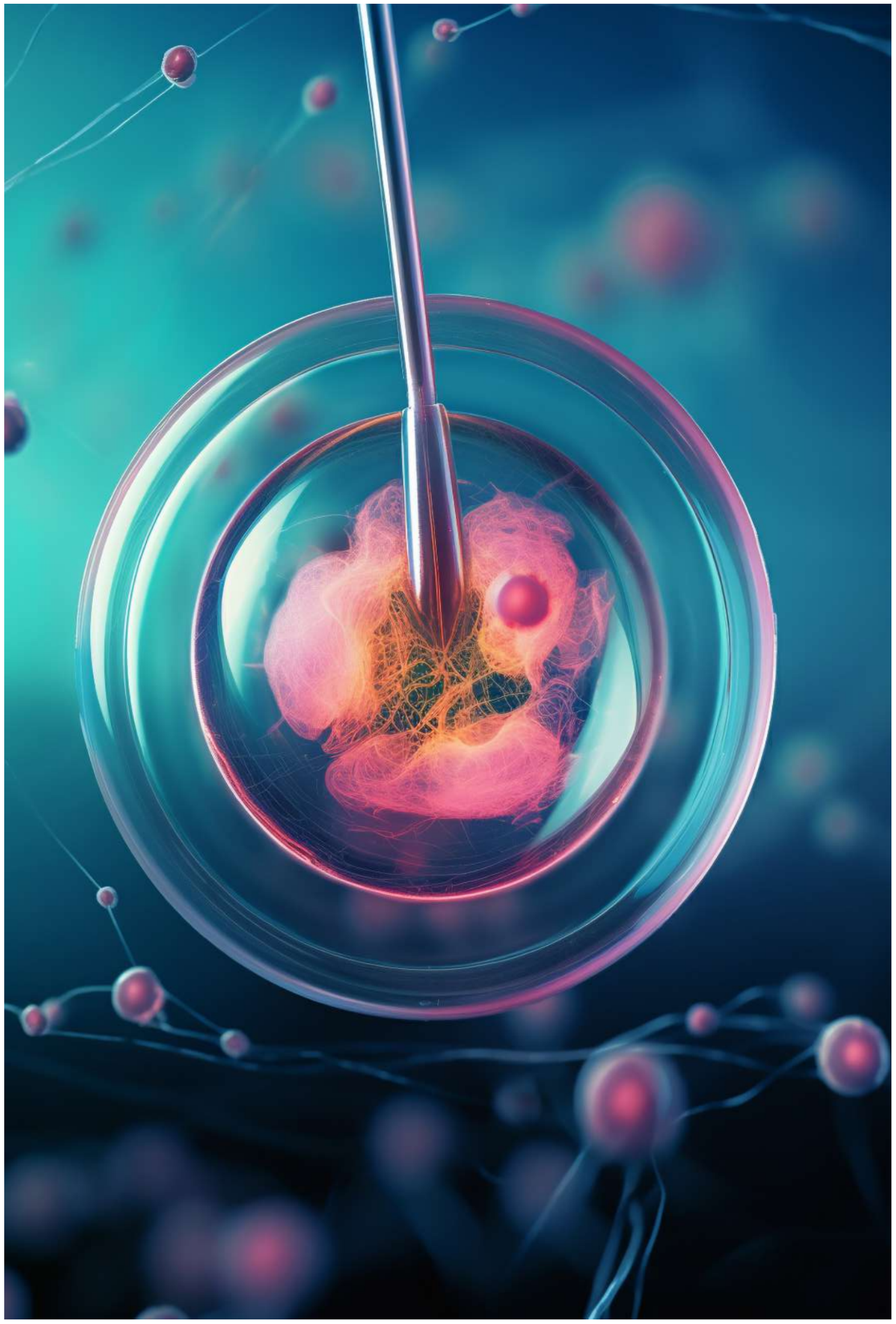
Large set of opportunities

Kinoko's products are like tempeh (fermented soy), but with improved taste and texture profiles, as well as a wider range of possible applications. Products under development include patties, sausage, and other types of processed meat products from a various set of substrates (quinoa, black beans). Beyond 2025, Kinoko Tech expects to be able to use its fungi expertise on nuts and seeds to produce protein balls.

Increasing penetration through private label

Kinoko Tech's business model is based on remaining a B2B private label provider, which it sees as the best way to make mycoprotein mainstream. To achieve this goal, it needs to partner with large branded processed foods manufacturers that also provide them with the equipment to scale production faster. This makes Kinoko's model easily replicable in Europe and Australia. Kinoko expects to start generating revenues this year, and significantly improve when production scales up.





CAPEX remain a key hurdle

The successful development of fermentation, mycelium and cellular agriculture companies relies on more capacities being made available.

- **Equipment providers**

Two main bioreactor types exist: stainless steel and single-use bioreactors. While single-use bioreactors can be used as a starter and to develop the process, stainless steel bioreactors will be more appropriate in the long term. The shift will also create a bioprocess challenge for companies as they grow.

FIG 25: FERMENTATION EQUIPMENT TYPES

	Stainless steel	Single-use
Definition	Uses a culture vessel made of stainless steel which needs to be cleaned between batches	Instead of a stainless-steel culture vessel, uses a disposable bag for each batch
Cost	2 to 3 times cheaper than single-use	EUR40K to several hundreds depending on size and complexity
Scale	Easier to scale, up to 200,000L	Mostly small, up to 200L
Advantages	- Process is very scalable, with large batches possible - Attractive cost	- Lower contamination risk - Less infrastructure needed - Flexibility

*Source: Stifel**

Single-use bioreactors are mostly used in the biopharma industry, which also achieved higher margins than food (twice as high EBIT margin on average). This creates strong incentives for manufacturers such as Danaher, Sartorius, Eppendorf, or Alfa Laval to focus on single-use bioreactors. Moreover, high demand from the pharmaceuticals industry (expected to grow mid-high-single digit in the coming years) creates a conflict of interest for manufacturers when choosing which demand to address.

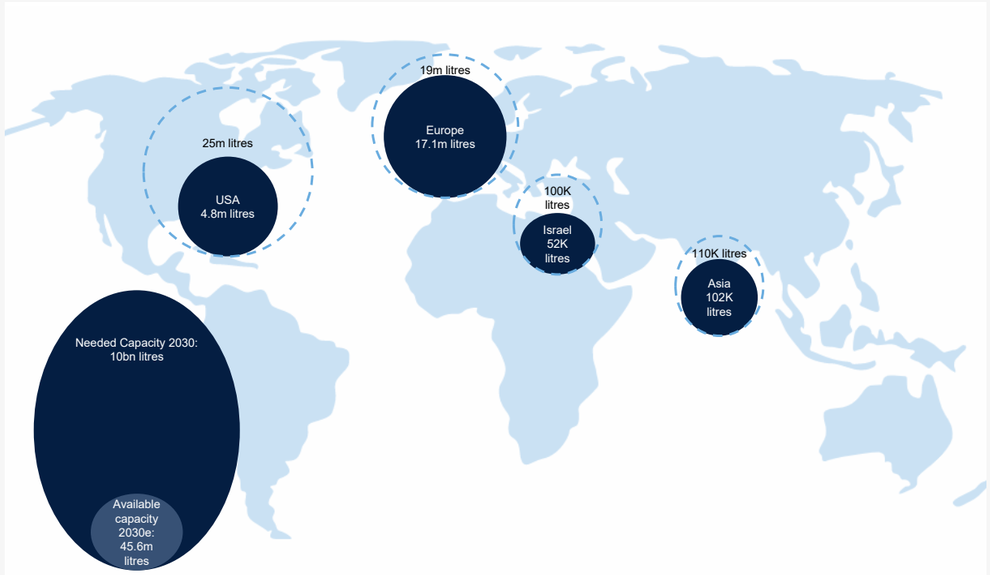
While most manufacturers acknowledge the cultivated proteins opportunity and are building relationships with players, their comments are not yet overly optimistic about the opportunity. We understand from our conversations with key manufacturers that they should be able to bring additional capacity to the market quickly, if it is seen as a profitable, accretive opportunity.

- **Needed capacities**

Only to produce proteins through fermentation, over 10 billion litres of food grade bioreactor capacities will be required by 2030. Currently, only 45.5 million litres are available or commissioned.

The capital investments required to fill the gap are estimated at between USD5bn and USD12bn (assuming 10,000 litres cost USD0.5-1.2m to build).

FIG 26: MAP OF THE FERMENTATION CAPACITIES



Source: Stifel Estimates, Capacitor by Synonym*

- **The need for governmental support**

Governments are increasingly involved in the infrastructure challenge, aware that equipment will be needed to support start-ups in reaching maturity.

On 12th September 2022, President Biden published an executive order on advancing Biomanufacturing for a Sustainable, Safe and Secure Bioeconomy, and pledged a USD2bn investment to support this initiative.

Israel's Innovation Centre has also launched a USD14.4m programme for infrastructure development to enable start-ups to share an R&D facility. In the Middle East, Abu Dhabi is working with Change Foods to build a fermentation facility.

Singapore offers attractive R&D incentives and facilities, with ScaleUp Bio bringing two new fermentation facilities to the market in 2023.

In Europe, most public investments are still focused on R&D with the majority of fermentation capacities built by independent companies. More focused investments in equipment will be needed to keep some of the best innovations in the field at home.

Protein isolates and texturing ingredients. Companies have been working on using the results of fungi fermentation as an ingredient to replace egg white and improve texture with a slight umami taste.

Because of its high protein and fibre content, mycoprotein can also be used as an alternative protein isolate in the plant-based alternatives space.

Case Study: Synonym

Synonym develops biomanufacturing financing and infrastructure platforms for all kinds of industry players, aimed at closing the infrastructure gap. Founded in 2021 it has raised EUR6.4m since inception.

We had a conversation with Alexandra Jaffe, in charge of Product and Commercialisation.

A gap to fill

As mentioned above, fermentation production capacities currently available are well below the requirements for fermentation companies to scale up and reach profitability. Large (over 100k litres) bioreactors are lacking, preventing start-ups from reaching maturity. Synonym has decided to focus on addressing this market gap by developing, financing, and building industria- scale fermentation capacity for food companies and other companies using fermentation to make sustainable bioproducts and ingredients. As part of this mission, Synonym created Capacitor, a digital tool that maps all current and future fermentation capacity in over 40 countries, enabling users to find infrastructure to help them scale.

Supporting fermentation companies' growth

Fermentation companies have a lot of R&D to handle to create the perfect process and product that will appeal to consumers. Building large-scale infrastructure is not generally a core competency of a fermentation start-up and therefore adds a lot of additional work to their already-full plates. Synonym aims to help fermentation companies by developing, financing and building this industrial scale fermentation capacity. By focusing on this piece of the value chain, Synonym can standardise the designs and processes, helping to reduce overall project costs and timelines.

Case Study: Mycorena

Founded in 2017 in Sweden, Mycorena uses fungi to produce a scalable, high protein and fibre ingredient, Promyc. The company has raised EUR33.2m since inception.

We had a conversation with Anton Johansson, CFO.

Fungi technology using liquid state fermentation

Mycorena's focus is to develop new technologies first using fungi, and then expanding into potentially new ingredients and formulations to generate benefits for the industry. The company has decided to use liquid state fermentation which it sees as more robust, secure, and scalable compared to solid state fermentation. However, Mycorena really sees its future as a technology provider that would license out its technology in order to grow, considering the JV structure as very interesting (especially in the Middle East).

From Promyc and Mycolein to Re: Food*

Promyc was the first ingredient created by Mycorena, with a versatile profile that helps alternative protein producers to remove off-taste or texture issues that typically come with soy and pea. Using Promyc also helps significantly reduce the list of ingredients, thereby improving the overall result. Mycorena has also developed Mycolein, which helps transform the fat, a key issue in plant-based proteins. Mycorena also received a grant from the EU as part of the LIFE RE: FOOD* programme working on the circular applications of mycelium.

A kingdom to consider

Together with Quorn, Mycorena recently issued a statement to the Nordic Nutrition Recommendation Committee to push for a change in how fungi is seen by food regulators. Not including fungi as a key source of protein is massively impeding the sector's development and ignores the huge advantages of these products.

Urgent need for infrastructure

Fermentation is a massive opportunity in the food manufacturing area but upfront investments in infrastructure as well as an acceleration on the regulatory and investment fronts are urgently needed to support the development of alternative food solutions to make our food chains more sustainable.

*LIFE RE: Food is a collaborative project between Mycorena and the EU to identify innovative processes for food waste treatment. The aim is to recycle waste into edible food products.

Case Study: Enough

ENOUGH was founded in the UK in 2015 and produces the Abunda mycoprotein, a food ingredient sold to large food companies to replace traditional proteins. Since inception, the company has raised EUR95m.

We had a conversation with Jim Laird, CEO and Elaine Ferguson, CFO.

Great, versatile ingredients

ENOUGH uses mycoprotein to make Abunda, a fermented food ingredient that helps increase protein and fibre content in manufactured products. ENOUGH's business model is focused on being an ingredient supplier across a wide range of products (whole muscle, patties, snacks). Enough supports customers with product application capability, addressing a range of ingredients (e.g a NO-chicken filler, NO-chicken schnitzel).

Change in business model

Since its foundation in 2015, the company has evolved from a technology licensing model to a JV model and now has its own production site that was inaugurated at the end of 2022 with production of 10k tons per year (in 220L tanks) and capacities to expand to 60kt in the medium term. With this facility, the company will be able to supply large quantities of the Abunda protein to processed food manufacturers and accelerate the penetration of mycoprotein globally.

Case Study: The Protein Brewery

The Protein Brewery is a Dutch company using a mycelium to transform sugar into a versatile, high protein food ingredient. The company was founded in 2017 and has raised EUR23.9m since inception.

We had a conversation with Jan Hendrik van Gilst, CFO.

A versatile fermentation platform

The Protein Brewery is an innovative developer of fermented food ingredients. It uses a fermentation process to create Fermotein®, a fungi-based dry powder that is highly nutritious and has a sustainable profile. It is very rich in proteins and fibres, contains essential unsaturated fatty acids, vitamins and minerals and is gluten free. Fermotein's other advantage, beyond its functional attributes, is a versatile flavour and colour direction due to neutral profile, which offsets a key issue with pea and soy proteins. A circular process is used to reuse heat generated during fermentation to preheat the drying process of Fermotein. The resulting dried product has a long shelf life can be stored and transported under ambient temperature conditions.

Route towards commercialization

The Protein Brewery provides alternative food ingredients. It isn't building its own brand but provides ingredients to food manufacturers, which enables them to access the market faster. Having already a demo plant where they produce Fermotein and a Food Experience Centre to test and develop product in food applications, they have started commercialization and scale up production. Commercialization will start with the US, where regulation is more accommodative, then Europe. Asia, especially Singapore is seen as potentially interesting thanks to the more favourable regulatory rules that apply over there.

Easy-to-operate brewing process

The advantage of Fermotein is its easy production process, that relies on locally available sustainable starch rich crops, which could be expanded to food side streams in the future. A scalable brewing process accommodates growth without requiring significant investments, an asset-light approach provides greater flexibility to adjust production levels and respond to changing market demands.

Once applications are developed, production will be very competitive. Expectations are that Fermotein will be able to compete with plant-based alternatives, without the off-taste and with a stronger nutritional value.

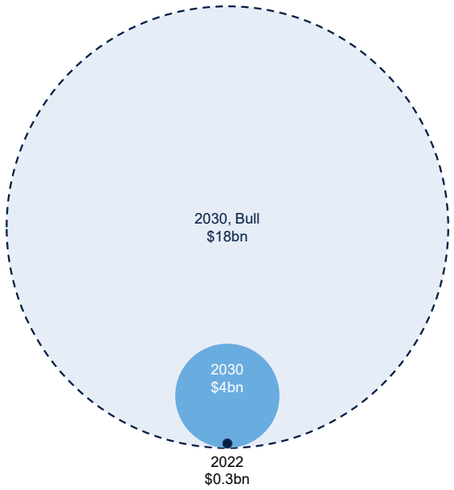
Addressable market

Stifel* expects the mycoprotein addressable market to reach up to USD18bn by 2030.

While Quorn has been active for almost 40 years, the mycoprotein market remains limited to its businesses, which generated revenues of USD300m in 2022. This represents roughly 3% of the meat alternative markets, the main market addressed at this point.

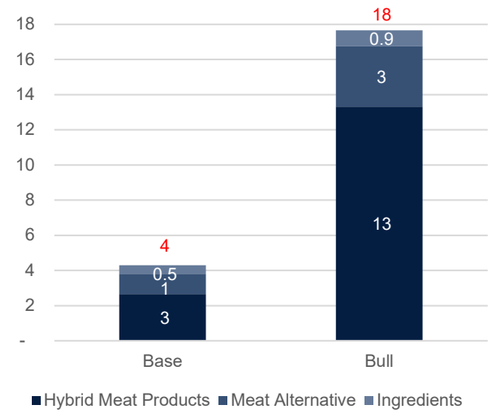
Our assumptions are based on a growing set of opportunities for mycoprotein, especially hybrid alternative proteins (where we expect mycoprotein could account for up to 50% of the recipe) and ingredients, as well as growing penetration. All assumptions are detailed in the table below.

FIG 27: MYCOPROTEIN TOTAL ADDRESSABLE MARKET



Source: Stifel, Statista*

FIG 28: MYCOPROTEIN ADDRESSABLE MARKET BREAKDOWN, 2030



Source: Stifel Estimates, Company Reports*

FIG 29: SUMMARY OF OUR ASSUMPTIONS

	Base Case	Optimistic Scenario
Hybrid Meat Products	1%	2.5%
Market ($bn)	3	13
Meat Alternatives	5%	15%
Market ($bn)	1	3*
Ingredients	2%	2.5%
Market ($bn)	0.5	0.9
Total Market ($bn)	4	18*

* Based on Base assumptions for meat alternatives market size in 2030 ($23bn). Assuming bull case, market would be $18bn and total market $31bn.

Source: Stifel Estimates, Company Reports*

Development concerns

- **Regulations**

It is theoretically easier for mycelium to obtain approval, especially if the company uses fusinarium venenatum which has been used by Quorn since the 1960s. New strains will have to go through Novel Foods, but awareness around mycelium should make the process easier.

- **Labelling**

Mycoprotein is still frequently excluded from protein source recommendations, which is a hindrance to further consumer acceptance. More clarity is required from nutritional authorities, together with retailers and producers, enabling mycoprotein to gain the popularity it warrants.

Mycorena and Quorn's open letter of April 2023 to the Nordic Nutrition Recommendations Committee (infra) is an important step towards better recognition of mycoprotein in coming years.

- **Product perception**

Clear labelling should allow mycoprotein to find its sweet spot on the shelf. As things stand, it fits between plant-based alternatives and meat, and the specific nature of mycelium complicates labelling. Once clarified, marketing efforts will be possible to support adoption and change consumer perception of mycoprotein.

Outlook

Mycelium still has a lot to offer to make our food system more sustainable at scale, with fewer regulatory burdens to go through. Infrastructure will remain the key issue, but mycoprotein's scalability will make it a key investment focus in the fermentation space.

FIG 30: QUORN AND MYCORENA'S OPEN LETTER

MYCORENA Quorn

Dear Nordic Nutrition Recommendations Committee,

Since the Nordic Nutrition Recommendations (NNR) were first drafted in 1980 and updated in 2012, a lot has changed. It is time to recognise that the current food system faces severe challenges, and we must do more.

While the current reform of the recommendations is welcome, the significant reviews conducted to consult research are fragmentary due to failing to consider alternative routes to a more sustainable food system.

It has been acknowledged that plant-based diets can help us move in the right direction. However, we find it essential not to neglect other life kingdoms and their role in our diets. It is time we stop feeding the binary narrative of either animal- or plant-based and acknowledge the existence and potential of alternative food sources. For instance, the fungi kingdom, a distinct kingdom in the taxonomic order separate from both plants and animals, has the potential to deliver high-quality nutritional protein. So, we would like to see fungi-derived protein recognised in food-based dietary guidelines in its own right – it is molecularly closer to animals than plants, by the way.

The current challenges of high carbon emissions, environmental degradation, and food insecurity necessitate new technology and alternative food production methods. Now is the time to seriously evaluate the environmental and health benefits associated with fungi as a source of protein and fermentation as a method for more sustainable food production.

Let us paint a more explicit picture. Through fermenting filamentous fungi, it is possible to produce a complete protein, mycoprotein. Besides containing all essential amino acids, it has a rich nutritional profile. Now imagine it is possible to produce this protein anywhere in the world in a matter of days through a process independent of climate conditions, requiring only a fraction of land compared to traditional agricultural methods. Finally, picture the vast arable lands needed for growing crops in contrast to an indoor vertical fermentation facility.

It might be worth looking into, right? After all, the revised NNR will inform the national guidelines and policy work of five Nordic countries and affect the consumption patterns of more than 25 million people.

Do not hesitate to contact us should you want to learn more.

Yours sincerely, Mycorena & Quorn

Ramkumar Nair
Founder & CEO Mycorena

Marco Bertacca
CEO Quorn Foods

P.S. Mycoprotein has been in Nordic supermarkets for over 20 years and is now produced here. We heard that food security is also a hot topic.

MEAT WITHOUT MEAT: CELLULAR AGRICULTURE RESHAPES PROTEIN PRODUCTION

SECTION 5

MEAT WITHOUT MEAT:
HOW CELLULAR AGRICULTURE RESHAPES PROTEIN PRODUCTION

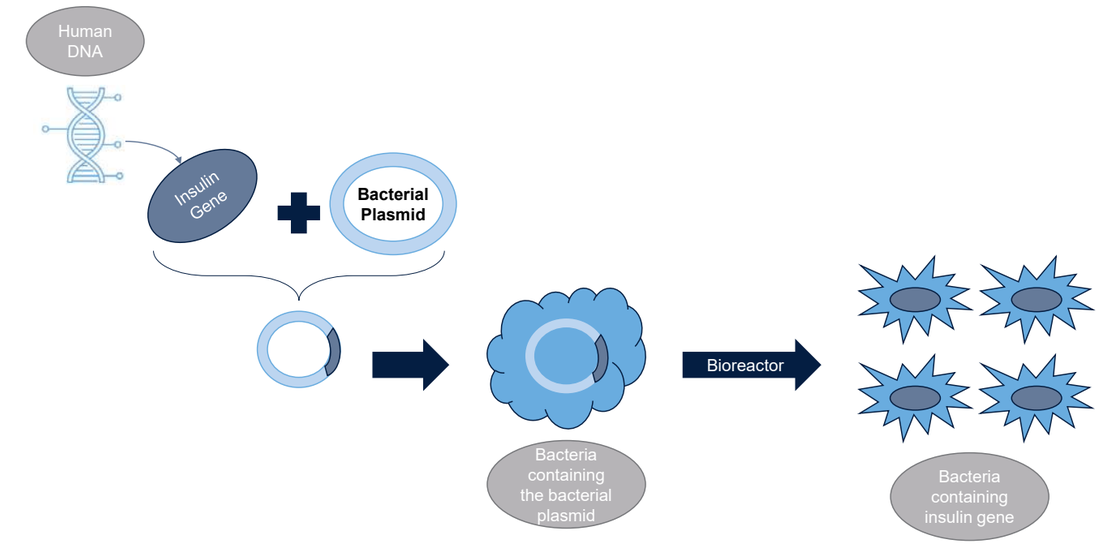
FIG 31: OVERVIEW OF THE CULTIVATED SPACE

*Source: Stifel**

Technology

Cell culture and replication has been used for a while in biotech. Insulin, for example, one of the most popular proteins needed by the human body, has been produced using cell culture for a while. The insulin gene is extracted from human DNA and combined with enzymes (bacterial plasmid) to generate a bacteria containing insulin gene with the ability to reproduce quickly.

FIG 32: ILLUSTRATION OF INSULIN PRODUCTION PROCESS

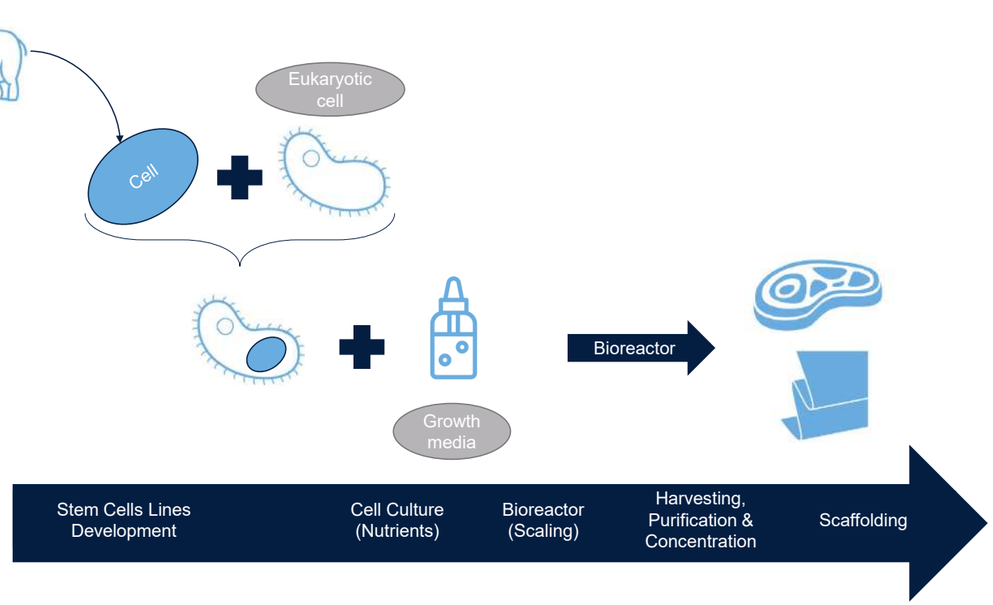


*Source: Stifel**

Since the 2010s, this process has been increasingly used for consumer applications (meat, textiles, beauty ingredients) and an increasing number of biotech companies are working on replicating meat, dairy and seafood using cell culture.

It is important to highlight a key distinction between insulin production and cellular agriculture. The former uses bacteria for protein production while cellular agriculture uses eukaryotic cells (cells with a clearly defined nucleus surrounded by a nuclear membrane) to replicate the cells as a product.

FIG 33: ILLUSTRATION OF THE CELLULAR AGRICULTURE PROCESS



*Source: Stifel**

Cellular agriculture is using three main types of stem cells:

- **Embryonic stem cells (ESCs)** offer the advantage of being easily differentiated and therefore the ability to generate muscle or fat. However, embryonic stem cells raise ethical concerns and are forbidden in several countries, thereby leading to the growing popularity of Induced Pluripotent Stem Cells.

- **Induced pluripotent stem cells (iPSCs)** are issued from somatic cells (skin or blood) and are then reprogrammed into an embryonic state that enables indefinite proliferation and reproduction of any type of cell. This technology has been developed since 2006 and is used in diabetes and cancer treatments for example.

- **Primary cell lines** are produced through a biopsy of a mammal's muscle or tissue, thereby enabling perfect reproduction. These stem cells offer more predictable and stable results, enabling quicker production scale-up, but have limited life-span and proliferation capabilities.

Pluripotent stem cells are cultured in vitro to be propagated indefinitely. Immortalised cell lines are adult stem cells (primary cell lines) that have been manipulated to generate indefinite proliferation and life-span and offer more predictable results.

The culture of stem cell lines requires the use of a **growth media** (or culture media), which is a solid or liquid designed to bring the necessary nutrients and energy to support proliferation of the cells. Growth media contains mostly glucose, amino acids, inorganic salts, vitamins, lipids and buffers, with the mix being tailored to the products being made.

A serum (high protein mixture supporting cell proliferation) can also be used but creates ethical challenges as foetal beef serum (harvested from a foetal calf) is often used. A growing number of companies are working on serum-free cultivated proteins.

Seafood is a challenge for growth media, as most media have been developed for mammal cells so far. Medaka cells are used at this point, but more research is needed to unveil the full potential of cultivated seafood.

Bioreactors support the growth and multiplication of cell lines before the cells can be harvested, purified, and scaffolded in order to give texture, if needed.

Biomanufacturing processes are evolving to provide processes in which cells can grow in suspension, removing a part of the texture challenge.

Texture is key in increasing penetration of cultivated products. Beyond taste, a good replication of traditional protein texture is required for the illusion to work, prompting consumers to adopt the alternative. Cultivated proteins have adopted various stances towards texture:

- Shredded products do not require scaffolding, texture comes with processing of the cells. This can be used for hybrid products which mix plant-based alternatives with cultivated ingredients and can do without scaffolding.

- Scaffolding is the process of adding texture to cultivated cells. Scaffolding can use microcarriers (beads) made from biomaterials, hydrogels and gelatine to give structure to the cells. Another way is to use 3D printing to give the cells the aspect desired.

FIG 34: SUMMARY OF STEPS, REQUIREMENTS AND CHALLENGES

	Definition	Requirements	Challenges
Cell Lines	Stem cells replicated to form cultivated proteins.	Biopsy, reprogramming of adult cells.	Reproducibility and consistency of the line, Genetic drift.
Growth Media	Nutrients used to grow and replicate the cells.	Mostly Glucose, Amino Acids, Inorganic salts, Vitamins, Buffers, Serum. Tailored to the cells being cultivated.	Use of unethical FBS, Bacterial contamination, supply challenges leading to soaring costs, need for specific formulation for some species (seafood), regulation.
Bioprocess	Large scale cultivation of cells in a bioreactor.	Bioreactors and a food-grade process; strains training	Bioreactor capacities and cost, process optimization; time.
Scaffolding	Process that gives structure and texture to the cultivated cells.	Microcarriers (beads), biomaterials, hydrogels. 3D printing can also be used. Polymers, collagen and gelatin are used in the process. Growing development of scaffold-free processes	Contamination risk, complexity to correctly reproduce the texture of traditional products, regulation.

Source: BG IRIS, The Good Food Institute

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The cultivated protein supply-chain and its challenges

Successful development of cellular agriculture requires a strong supply chain

FIG 35: CELLULAR AGRICULTURE SUPPLY CHAIN SUMMARY

Source: BG IRIS, The Good Food Institute

- **Cell line development:** several pharmaceuticals companies such as Valneva have experience in developing cell lines, making a large library of cells available. Start-ups are also working on further optimisation of cells for the cellular agriculture process.

- **Growth media:** creating animal-free, efficient and affordable growth media is a key challenge for the industry. Although growth media formulation has been known for a while, with large companies operating in the field (Merck, Thermofisher) it still needs to be tailored to different types of products in order to support vertical and horizontal cell growth. The cost of growth media has been surging recently due to increased demand across the industry, which leaves room for innovators working on serum-free, in-house developed growth media

- **Biomanufacturing process:** as the industry grows, plants are growing too, creating scale issues which are not in the core competencies of innovative cellular agriculture companies. Bioreactor manufacturers and CDMOs will be key to support growth from a process standpoint. Inside the biomanufacturing process, bioreactors are a key issue. Various sizes of bioreactor are needed as the sector scales up from 2K litres for proof of concept to over 200K litres, at full capacity. This creates growing demand for equipment. The sector is dominated by large industrial players such as Alfa Laval and Sartorius, which should have the capacity to support growth in the sector, although the magnitude of excess demand remains uncertain. To help close the capacity gap, some players are building food grade CDMOs. For example, Synonym and Liberation Labs are helping start-ups to scale up in the US.

- **Microcarriers, scaffolding and 3D printing** are not a necessary step in all cultivated protein processes, but enable the product to gain in texture, which is key for their widespread adoption. The products issued from the bioreactors can also be assembled through 3D printing and spinning technologies, which can be particularly helpful for replicating the fat and muscle architecture of meat.

Case Study: CellRev

CellRev develops a cell culture technology for applications in pharma and food, increasing cell proliferation in a bioreactor that can work without serum. The company was founded in 2018 and has raised EUR3.6m since inception.

We had a conversation with Chris Green, CEO.

Making cell cultivation more efficient

CellRev's technology sits on the upstream side of the cellular agriculture process, with its adherent cell processing platform helping companies in both the biopharmaceutical and cultivated protein space to both develop and manufacture cellular products. More specifically, its technology can be used as a seed train (efficient seeding of downstream reactors where cells are used as expression systems) and proliferation (meaning the creation of a significant mass of cells for downstream processing). CellRev's continuous cell processing solution offers many benefits such as improved process control, stability and increased yield while being inherently scalable. The company's platform uses a proprietary cell detachment system to enable continuous manufacturing.

For research and manufacturing

CellRev's cell processing platform can translate from process development (which remains a priority for many cultivated protein companies) to commercial manufacturing with relative ease. The technology has applications in food, therapies, and biopharmaceuticals. Food production offers a significant opportunity for the company with the technology unlocking the scalability and cost challenges currently facing the cellular agriculture field.

Sitting on the new generation of cultivated protein companies

CellRev is already conducting early-stage development work with companies in the cultivated protein space. These parties are beginning to see the benefit of externalising parts of their process to focus on end-products or commercialisation. Long term, the company aims to licence its technology on an industrial scale, but for now, the focus is on scaling up and supporting customers in establishing commercially viable bioprocesses with its patented platform.

History and developments

Cell replication technology has been available for a while, but applications in the food area did not kick off before 2013, when Mosa Meat unveiled the first cultivated steak.

Costs were then extremely high, but this set a precedent for more companies to develop the technology. Three distinct phases of developments can be identified, from a very internalised one and small batches of production at an expensive point to more externalisation, larger scale production and larger batches being produced in the 2020s, with some products even starting to be approved.

FIG 36: CULTIVATED PROTEINS DEVELOPMENT

	2013	2018	2023	2030
Development Stage	First	Second	Third	Fourth
Technology	Nascent, mostly derived from the Pharma industry	Efficiency gains, proof of concept at larger scale	Large scale production	Mass production
Infrastructure	Inexistant	In development, depending on CMO	Some CMO developing specifically for cell-based, more bioreactors being built	More capacities being built, with a split between CMOs and in-house large-scale facilities
Level of Internalisation	Fully in-house	Starting to developing partnerships with manufacturers, industrials	More externalisation of the supply chain, splitting commercial and scientific	More externalization for cell lines, growth media and bioprocesses, creating further economies of scale
Production	Limited amount	Small batches of c.100 metric tons	Larger batches up to 1000 metric tons	Slowly reaching mass production, millions metric tons, in line with infrastructure development
Cost	Over $300,000 for a beef patty	Declining though still factor 100x compared to traditional proteins	Mostly CAPEX related, still high premium compared to meat	Slowly reaching parity with scale, though still pricing at a premium to traditional protein
Regulation	Inexistant	Novel Food framework, Singapore approval	USA Approval Israel moving forward	Europe & global approval
Consumer Adoption			+	++
Development Milestone	Mosa Meat steak, proof of concept	Large corporates interest	First products commercially approved	Full scale production facilities

*Source: Stifel**

Applications

Meat is a natural product for cellular agriculture, and what the process started with. It offers a wide range of opportunities in terms of the species that can be chosen and the type of cuts (patties or a replication of steak). The industry is still novel at present and companies are experiencing various formats and species, a few of which are studied below.

Case Study: Aleph Farms

Aleph Farms was founded in 2017 and is an Israel-based cellular agriculture company that is currently producing cultivated beef. The company is moving forward with the launch of its first product line, Aleph Cuts, in initial markets upon regulatory approvals. Aleph Farms has raised more than EUR110m since inception.

We had a conversation with Didier Toubia, Co-founder & CEO.

Focusing on the larger part of emissions
Aleph Farms decided to focus on growing high-quality products from cells sourced from cows. The reasons for this focus are climate impact (cattle have the highest environmental footprint across all of animal agriculture) and market impact (cattle products deliver the highest value in global markets, shortening the timeline to price parity).

Its first Cut is a thin-cut beef steak grown from cells of a premium Black Angus cow named Lucy from California. Starting later in 2023, pending regulatory approvals in Singapore and Israel, the company will introduce Aleph Cuts in limited quantities, offering exclusive tasting experiences curated in collaboration with select partners.

One species, many opportunities
Although already very technologically advanced, Aleph Farms is not currently expanding into products from other animal species, as the company prefers to first maximize the many opportunities associated with cow cells both within the food sector and also outside of food (e.g.,for example leather), as only 30-40% of the cow's body weight is edible. As opposed to a species-agnostic approach, Aleph's current focus on cattle products enables the company to concentrate its efforts on a species that is especially resource-demanding and also achieving price parity faster.

Aggressive cost reduction to support product development.
It is currently very expensive to produce cultivated meat, with the main cost driver being the growth media for which demand from pharma and food have recently surged. Moving to scale, cost reduction of growth media will gradually help reduce the cost of production at-scale and therefore drive price parity with conventional products. At the time of initial launch, Aleph Cuts will be priced similarly to ultra-premium conventional beef, but the company is taking various steps to achieve price parity with more of the conventional beef market within a few years of launch. Large food manufacturers have a key role to play in supporting the ramp-up in production capacities and commercialization.

A clear road to market
Although Aleph Cuts is ready for commercialisation, it will not appear in supermarkets overnight. The company has a clear road to market, planning to work with chefs before expanding to food service and retail. Aleph's growth strategy includes conducting joint operations with food and meat industry incumbents, leveraging their expertise and infrastructure to accelerate scale-up and commercialization.

Case Study: Vital Meat

Vital Meat is the French spin-off from Group Grimaud focused on producing cultivated chicken, focusing on a B2B model.

We had a conversation with Olivia de Talancé, COO.

Rooted in science
Vital meat is the cultivated meat venture of the Groupe Grimaud, a well-known French specialist in animal genetic selection. The group is also known through another subsidiary, Valneva, a biotech company specialised in the development of prophylactic vaccines using avian cell lines.

In 2018, Groupe Grimaud decided to look beyond pharmaceuticals and explore new opportunities where the Valneva technology could be applied through intellectual property licensing. Given the cost of farming and raising meat as well as the related environmental issues, the company decided to develop cultivated meat through Vital Meat with the aim of scaling production and then being able to apply for regulatory approval.

B2B the key to widespread adoption
In the short to medium term, Vital Meat aims to sell its chicken cuts in B2B applications, meaning that consumers will not obtain a branded Vital Meat product but will consume it as an ingredient in finished products purchased from Vital Meat's partners. This is a perfect way to bypass the psychological barrier related to cultivated meat and encourage large scale adoption.

Vital Meat's products also enable companies to reduce their ingredients list, a key issue with plant-based alternatives, and therefore have a cleaner label product, with a similar or even improved nutritional profile compared to chicken. Coming through B2B also makes it easier for producers to absorb the premium to traditional chicken, as the ingredient represents a smaller part of the total recipe.

And a large set of opportunities beyond
Vital Meat's expertise in avian cells opens several doors to expand the products offered over the long term. A possibility is also to work with plant-based alternative producers on hybrid products, which would help improve the taste, texture, and nutritional profile of currently developed alternative proteins. Vital Meat is working with both large caps in the sector and smaller companies to find the rationale applications and adapt its offer to demand from various sets of companies.

A space that still requires structure
Vital Meat is currently working on its pilot plant and acknowledges there is still some way to go before full commercial scale is reached, where support for infrastructure building will be needed, given that CMO is harder to use in this space due to high intellectual property barriers. The key issue remains regulation, although positive progress has recently been made, at the European level with the EFSA stating it is open to looking at submissions from companies and working closely to establish requirements for commercial use, and at a more local level, in France where the Senate has created a commission on cultured meat, interviewing several actors in the space to understand the issues and make progress. However, in the short term, Vital Meat remains realistic and will focus on more advanced geographies to make its product progress commercially.

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Regulation

Regulatory approval will be key to unlock the full potential of the technologies covered in this paper.

- **Key approval steps**

If a microorganism has been consumed prior to a certain date (1997 in Europe, 2006 in Israel) and is not genetically modified, only food safety approval is required. the product only required (e.g. Fusarium Venenatum in mycoprotein).

When microorganisms are engineered and have not been consumed prior to a certain date, they are classed as Novel Foods and a full safety review of the ingredients and processes is required before products can be commercialised. Regulatory authorities are still working on the right processes and regulations. The table on the left summarises the current regulatory standing across technologies and countries.

- **Regulatory timeline**

Despite quick progress being made, regulatory timelines remain key for start-ups when choosing their focus areas.

Singapore and the US are the two most accommodative countries, with products across the fermentation, mycoprotein and cellular agriculture spaces reaching commercialisation phases.

In Singapore, Good Meat's cultivated chicken has been commercially authorised since 2020. The country works closely with all players in the space to create the conditions to become a cultivated meat leader. The most recent progress was made in 2023 when Good Meat's serum free media was approved by the SFA.

The US has recently accelerated sharply in the cultivated meat space. After receiving a "No Question" Letter from the FDA in November 2022 (just a year after filing for approval), Upside Foods and Good Meat received Label Approval from the USDA on 16th June, followed by the USDA Grant of Inspection a week later.

This means, Upside Foods and Good Meat's cultivated chickens are now approved for sale in the US, a major milestone for the space!

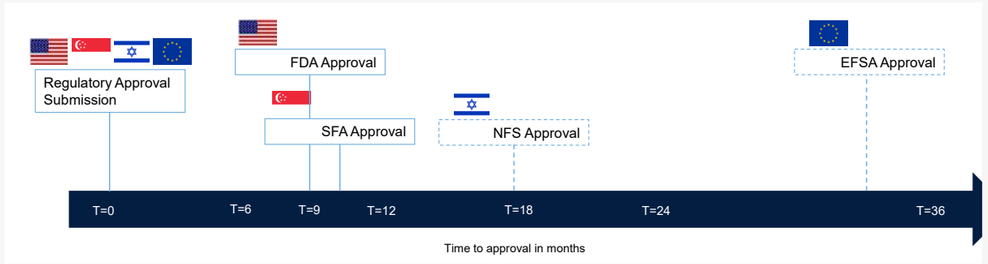
Approvals in Singapore and the US have set a precedent, and process time should shorten below the one-year time frame.

Israel is expected to follow with an estimated delay for approval of around 18 months.

Recent progress in the US should be a wake-up call for Europe, which is still a key laggard in the field with lengthier processes. Regulators have still not started to look closely at fermentation and cultivated protein products, and some countries such as Italy have already taken a strong stance against these products. Although positive signals have been received from both local and regional levels, approval for these products in Europe will still take at least 18 months, with more sensitive expectations at around 24 to 36 months.

Delaying approval dramatically impacts the development of fermentation, mycoprotein and cultivated protein start-ups in Europe, As such, Europe must act urgently to avoid talented start-ups flying away and developing in other, friendlier countries, leading the region to lose its innovation leadership.

FIG 37: APPROVAL TIMELINE ACROSS KEY COUNTRIES



Source: BG IRIS, The Good Food Institute

At the time of drafting this white paper, it's worth noting that on 26th July, Aleph Farms announced their application submission for cultivated meat approval in Switzerland and a pre-market authorisation to the UK FSA on 4th August. Although Switzerland and the UK do not depend on EFSA for food approval, we see it as a positive first sign that could unveil significant acceleration in the current expected timeline for cultivated protein's availability in Europe.

- **Greater labelling clarity**

Once products have been approved, the question of their labelling will become key.

For ingredients derived from fermentation, we expect little change in the labelling process. However, brands using these ingredients to clean their recipes might benefit from being vocal about it. However, proper assessment of the nutritional values of these ingredients (fibre and protein content in particular) will be key to widespread adoption of the products.

A proper labelling of mycoprotein products will be key to enable products to find their right spot on the shelf and enhance consumer adoption of these products.

Finally, labelling remains a key question for cultivated proteins, particularly when sold unprocessed to consumers. Upside Foods obtained approval for "cell-cultivated chicken" from the USDA and we expect most cultivated proteins to have similar labelling. The question of hybrid products (using cultivated proteins to improve plant-based products recipes) remains, especially whether they could be considered vegan or not. Theoretically there is no animal killed, but with animal cells being used, there is still a debate to be held.

Case Study: GOURMEY

Founded in 2019, GOURMEY produces cultivated foie gras for B2B2C commercialisation. The French company has raised EUR60m since inception.

We had a conversation with Isabelle Chabot McNeill, CFO and Clémentine Papon, Chief of Staff.

Building Europe's largest cultivated meat hub
Paris-based GOURMEY is the global frontrunner in premium cultivated meat. They aim to accelerate the world's transition toward ethical, sustainable, and healthy meat.

The company pioneers the creation of sustainable culinary-grade meats using real animal cells grown in bioreactors, reducing environmental impact.

Established in 2019 by ex-L'Oréal CEO Nicolas Morin-Forest, molecular biologist Dr. Victor Sayous, and cell biologist Antoine Davydoff, GOURMEY now comprises a 60-strong team specializing in gastronomy, food sciences, bioprocess engineering, data science, and stem cell biology.

Following their Series A funding, they plan to open a 46,000-square-foot facility in France, Europe's largest cultivated meat hub, to manufacture and commercialize their first product line. They also aim to triple their team size and diversify their cultured meat offerings.

Reinventing iconic delights
Their world-first flagship product, cultivated foie gras, has received critical acclaim from Michelin-starred chefs and the press (Bloomberg, Sifted, New York Times, FT), and is already followed by other sustainable premium meats.

Upon receiving regulatory approvals, they will first introduce their flagship product to the premium food service sector, then to broader markets. Collaborations with distinguished chefs and premium meat distributors are being forged.

Fusing scalable biotechnologies and culinary arts to maximize impact
While cultivated foie gras is their immediate focus, they're developing a scalable stem cell production platform to broaden their product range in the near future, enabling them to penetrate deeper markets with further high-quality cultivated meats.

Seafood is another key area of development, although more recent than meat applications, with companies trying to address both fish (salmon, with Blue Nalu) and shellfish products (such as Mermade Seafood). Due to its more nascent history, the products are still under development, with identification of the cell lines and adequate growth media ongoing.

Case Study: Mermade Seafood

Mermade Seafood is an Israeli company working on cultivated shellfish and focusing on scallops. The company was founded in 2021 and has raised EUR3.3m since inception.

We had a conversation with Daniel Einhorn, Co-founder & CEO.

Seafood interest (especially shellfish)
The cost of development of cell-based proteins has made it essential to pick premium products that make it easier to break the cost barrier. That's why Mermade has decided to focus on shellfish, in particular scallops. Because of the nature of scallops, cells are also easier to replicate with decent replication times and therefore a very scalable concept.

Need for cheaper growth media
The cost of growth media is a key headwind to the development of cultured seafood. In particular, the recent surge in demand for growth media has led to an explosion in costs, and Mermade has therefore decided to work on developing its own and thus become independent from large producers. This is the company's key concern now, before even getting into larger scale production.

Investments remain a headwind
Beyond doubling times, the investments needed to scale up production volumes are essential for Mermade, and partnerships with large companies will help there. The company sees a slightly better reaction in the seafood industry where large firms have seen their meat counterparts act and realise they cannot miss out on that opportunity, but still see some cold feet here which can impede the development of cell-based products.

Other meaningful applications include dairy, as mentioned in the Bon Vivant case study, but also fat replication which Hoxton Farms has been working on. Anything cellular can theoretically be replicated through cellular agriculture.

Case Study: Hoxton Farms

Hoxton Farms is a British company working on cultivated fat that can be used in hybrid products. The company was founded in 2020 and has raised EUR24m since inception.

We had a conversation with Ciara Cronin Albert, Head of Business Development.

Fat to drive further plant-based penetration

Hoxton Farms started from the observation that the taste of plant-based alternatives is often a limiting factor to their widespread adoption. With cell cultivation, the company makes real animal fat without animals, which can then be added to plant-based recipes and replace plant oils. Beyond taste, animal fat improves the texture profile and mouthfeel of the products.

A cost par product

Because of the lower R&D intensity of cultivating fat compared with meat or seafood, fat is easier to scale and produce and could thus be widely adopted earlier. Moreover, because cultivated fats help improve the taste and flavour profile of plant-based alternatives, they enable manufacturers to save on additional flavouring costs and thereby clean up the label. This will enable Hoxton Farms' fat to be at cost parity with plant oils and ingredients as soon as scale is reached.

But a need for scale

To capture the market and make its products widely accepted, Hoxton Farms will need to scale, and therefore move to facilities that generate high production volumes. Supportive regulations in Singapore, Israel and the US (to name a few) are enabling this which could allow them to achieve industrial production by 2026.

Addressable market

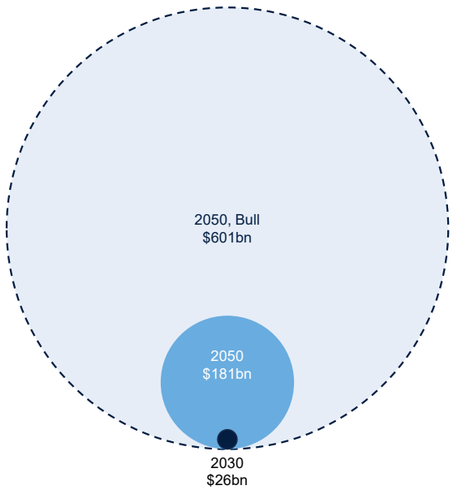
Stifel* estimates the addressable market for cellular agriculture products could reach USD28bn by 2030 and USD181bn by 2050.

Food applications for cellular agriculture remain nascent and face tough regulatory hurdles and despite the recent progress made globally, significant adoption prior to 2030 seems unlikely. 2050 would be a more realistic time horizon, enabling both the regulatory and infrastructure issues to be resolved.

Addressable market estimates are based on expected penetration across meat, seafood, dairy and ingredients. Our base case scenario assumes the total addressable market would reach USD26bn by 2030.

For 2050, assuming mid-single digit growth in underlying markets and faster penetration, our base case scenario would result in a total addressable market worth USD181bn.

FIG 38: ADDRESSABLE MARKET FERMENTATION



Source: Stifel Estimates, Company Reports*

FIG 39: CULTIVATED PROTEINS PENETRATION, 2030 FORECAST SCENARIOS

	Base Case	Optimistic Scenario
Meat	0.5%	3%
Market ($bn)	12	69
Dairy	0.5%	2%
Market ($bn)	9	46
Seafood	0.5%	2%
Market ($bn)	5	19
Ingredients	0.25%	1%
Market ($bn)	1	5.3
Total Market ($bn)	**26**	**139**

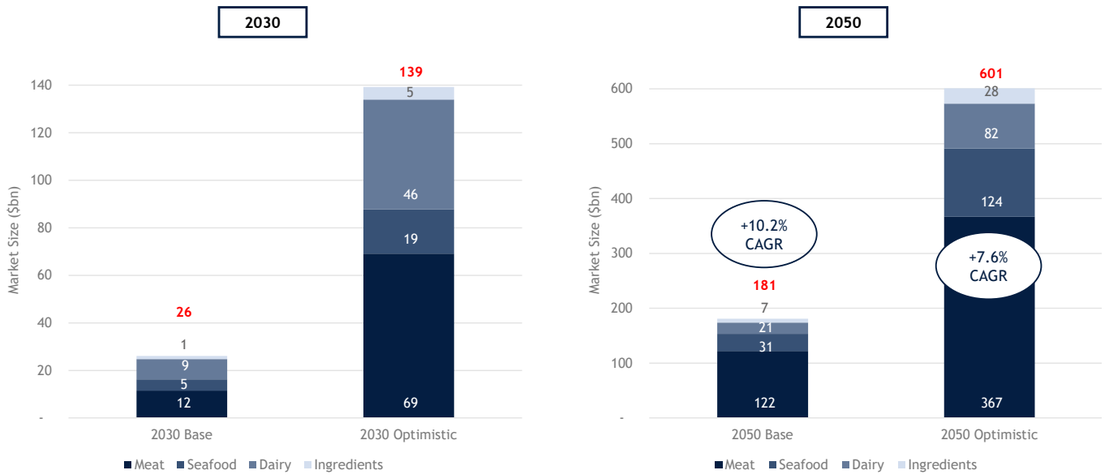
Source: Stifel Estimates, Company Reports*

FIG 40: CULTIVATED PROTEIN PENETRATION FORECAST, 2050 ESTIMATES

	Base Case	Optimistic Scenario
Meat	2%	6%
Market ($bn)	122	367
Dairy	1%	4%
Market ($bn)	21	82
Seafood	1%	4%
Market ($bn)	31	124
Ingredients	0.5%	2%
Market ($bn)	7	28
Total Market ($bn)	**181**	**601**

Source: Stifel Estimates, Company Reports*

FIG 41: SUMMARY OF CELLULAR AGRICULTURE ADDRESSABLE MARKETS, BASE AND OPTIMISTIC VIEWS



Source: Stifel Estimates*

The way to more acceptation

In this section we review the hurdles cultivated proteins will face to unveil their full potential.

- **Regulation**

Approval in Singapore and more recently in the US will enable faster consumer adoption of the products, but worldwide regulatory approval of cultivated proteins will be needed to scale their development and commercialisation.

- **Infrastructure and equipment**

Many cultivated protein companies are still on pilot plants with very limited production capabilities. Scaling up production will be a key step towards commercialisation at affordable prices. However, extensive investments in equipment and infrastructure will be required to achieve full scale development.

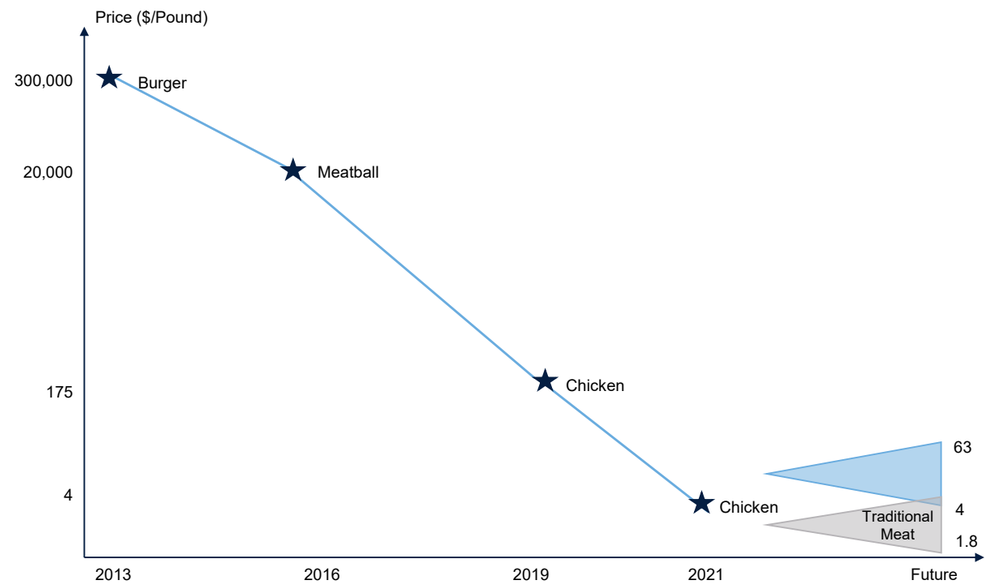
- **Production process**

Doubling time (time taken by cells to replicate) is a key KPI in cellular agriculture. This time has dropped from 6-18 months to three weeks over recent years, and a milestone was crossed by Meatable, which now only takes eight days to produce a full sausage, thanks to doubling time declining to 24 hours. Reducing doubling time and therefore accelerating the production process will be key for the scalability of cultivated proteins.

- **Cost**

Although costs have fallen, the production cost of cultivated proteins remains well above those of traditional alternatives. While a price premium is warranted, reducing the gap with traditional proteins will be essential to increase consumer adoption.

FIG 42: CULTIVATED MEAT PRICE EVOLUTION

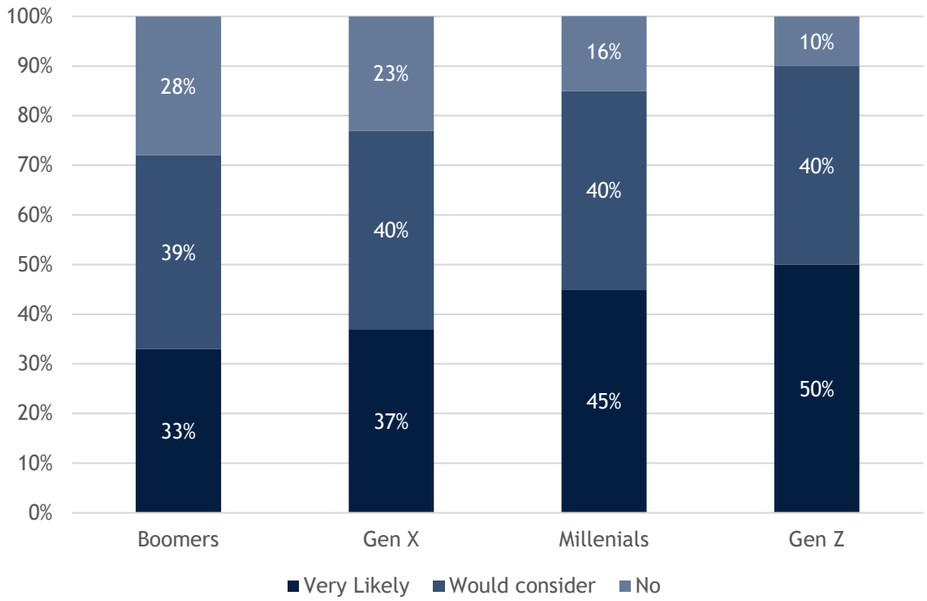


Source: McKinsey, Stifel Estimates*
2021 production cost was made with mixed plant proteins

- **Consumer adoption**

Consumer perception of cultivated proteins will be key to widespread adoption. The idea of meat cultured in a lab is often a major barrier to consumer trials. We believe younger generations, driven by sustainability and curiosity, will be keener to try it, and lead the way for consumer adoption, while the older generation might see a lower acceptance rate.

FIG 43: OPENNESS TO TRYING CULTIVATED MEAT, BY GENERATION



Source: US & UK Consumer Adoption of Cultivated Meat: A Segmentation Study, K. Szejda et al., 2021

- **Sustainability in question**

Cultivated proteins claim they generate less GHG emissions and consume less water than traditional meat. However, at this point no full-scale production has started and no strong comparison point is therefore available. A risk is that a growing number of investors and consumers will start asking for real time data on the environmental impact of these products and that the environmental credentials could start to fall.

Outlook

The journey for cultivated proteins to become widespread will clearly be longer than for precision fermentation and mycelium, and large-scale commercialisation before the 2030s seems unlikely. However, if investments and regulations follow, the field of opportunities for cellular agriculture is unlimited.

OTHER CONSUMER APPLICATIONS OF **FERMENTATION**

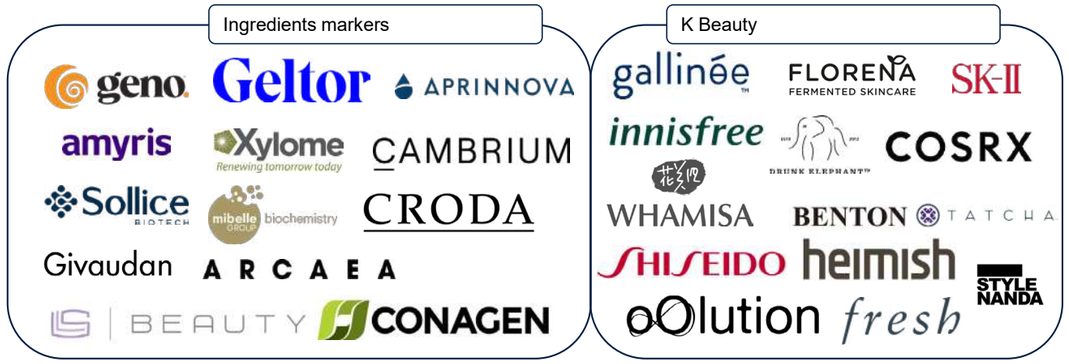
SECTION 6

OTHER CONSUMER APPLICATIONS OF **FERMENTATION**

Several companies use fermentation for ends that are not related to our food system but which help solve environmental or ethical problems especially in Beauty and Fashion.

Creating more sustainable beauty ingredients

FIG 44: OVERVIEW OF THE FERMENTATION IN BEAUTY MARKET



*Source: Stifel**

Beauty is constantly looking for innovation and new ingredients. Petrochemicals have been a major ingredient in beauty, for example in butylene glycol. Many ingredients are also issued from unsustainable sources, such as squalene which comes from shark's livers.

With a USD34bn size and 5-6% annual growth, the cosmetic ingredients market is very attractive. Ingredients players and biotech companies try to bring new, sustainable solutions to the market, and a growing number of alternative ingredients are made from precision fermentation. Squalane, produced by Amyris, is a sugar cane-based replacer for squalene, in which microorganisms transformed sugar cane into synthetic squalene. Geno, an American biotech company based in California, produces Brontide®, a butylene glycol sourced from natural plant sugars, and recently announced a partnership with Kao, Unilever, and L'Oréal to bring sustainable alternatives to palm oil to market.

Biotech derived ingredients can grow high single digit, outpacing growth by traditional ingredients (mid-single digit) as they fit into the search for cleaner beauty that consumers have been asking for.

M&A activity is set to peak in this area as large ingredients players such as Givaudan or Croda internalise the most promising innovations for their clients.

The trend is supported by beauty trends coming from Asia, with K-Beauty and J-Beauty from Korea and Japan becoming increasingly popular, and their focus on using less, more natural products on the face. Fermented cosmetics are very popular in these countries, with claims that they offer more concentrated actives, with better skin absorption as well as improved conservation and more nutrients for the skin etc.

Case Study: Geno

Geno is an American biotech company working on providing sustainable materials to a wide range of industries (fashion, beauty, home care). The company was founded in 1998.

We had a conversation with Sasha Calder, VP of Impact and Joe Danehower, Corporate Development.

The Biotech making Fashion and Beauty more responsible

Geno has been in the news recently for its partnership with L'Oréal, Unilever, and Kao in sustainable palm oil alternatives. However, their actions to make our industries more sustainable do not stop there. Since 2021, they have been working with Lululemon to develop a plant-based nylon (products called Nylon 6 and Nylon 6.6). They have also developed Brontide®", a plant-based butylene glycol (a molecule that stabilises the water and hydration in beauty products, originally made from fossil oil).

Agnostic technology

The force of Geno's model is the platform it has developed, enabling it to use diverse plant feedstocks (meaning it can use any sugar source) but also explore other feedstock sources. The company has extensive knowledge of how to engineer microbes and create the desired products, enabling them to serve a large range of customers.

Importance of scale

Our conversation with Geno was highly informative, especially concerning the company's success, which has been built on their ability to successful scale technologies like Renewable bio-BDO™ (bio-1,4-butanediol) produced by the Geno BDO™ process technology from plant sugars instead of fossil feedstocks at scale. To make our world more sustainable, materials need to be produced at scale, which the group has been focused on when picking areas of interest. This is bearing fruit, with regulatory, consumer and brand support (ban on products linked to deforestation) and accelerating demand for Geno's knowledge.

2 Alternative textiles in Fashion

FIG 45: OVERVIEW OF FERMENTATION IN FASHION MARKET

*Source: Stifel**

Fashion is responsible for 10% of global GHG emissions. This creates an urgent need for sustainable solutions in textiles. A large proportion of textile production still depends on animals.

Leather material accounts for 40-45% of the personal luxury goods market materials used in fashion, while cotton uses a huge amount of water. Fermentation, through both cell-based replication of leather or mycelium use to create alternatives to leather, offers great possibilities. Importantly, biotech and precision fermentation enable the creation of new materials with enhanced characteristics which are particularly interesting for the sportswear industry. As highlighted above, Geno is working with Lululemon on an alternative to petrochemically-made nylon.

Several hurdles still need to be addressed for these new materials to become predominant, price and volume being major ones. These new technologies will soon be capable of replacing the amount of textiles being produced from traditional sources.

For sportswear, performance is a key aspect and although we believe biotechnology can provide new, better materials from renewable sources, these materials will need to address the objectives and expectations of sportsmen and women.

As cost remains a key challenge, Luxury brands will lead the adoption of these new materials. Kering is leading the way through several investments and partnerships with innovators in both the mycelium and cell-based spaces. Luxury companies also benefit from extensive experience with leather tanning, enabling them to find innovative ways to use these alternatives. Adidas is also increasingly working on sustainable materials, and recently unveiled a limited series of mycelium-based Stan Smith shoes together with mycelium company Mylo.

FIG 41: EXAMPLES OF MYCELIUM USES IN FASHION

Source: Mylo Website

FIG 42: BALENCIAGA COAT REALISED WITH EPHEA™, LAUNCHED IN MARCH 2022 AT PARIS FASHION WEEK

Source: Image courtesy of Balenciaga

Leather materials account for 7.5% of leather goods prices and therefore represented a EUR4.7bn market in 2022. Assuming 6% annual growth, the total leather market would reach EUR7.5bn in 2030 and leather alternatives could reach c5% penetration by then, or a EUR0.38bn addressable market.

The global textiles market (cotton, wool, chemical, silk) is expected to grow mid-single digit to reach USD3,047bn by 2030. Sustainable fibres currently account for 1.8% (USD30.5bn) of the market and we estimate they could penetrate up to 5% of the market by 2030, reaching USD152bn (or 22% CAGR growth).

The total addressable market for fashion applications of fermentation is expected to reach USD152.4bn by 2030.

FIG 46: LEATHER MARKET COMPARISON

Source: Stifel Estimates*

FIG 47: TEXTILE MARKET COMPARISON

Source: Stifel Estimates*

Leader's View: Kering

Be an investment partner across technologies

Through Kering Ventures, the second largest luxury group is building a prime partner position with emerging technologies that have an impact on its products, such as new materials derived from cellular agriculture or mycelium. The group has built a structured team around its ecosystem and has its tanning factories working with these new materials to see how they can be exploited. They regularly check in on new materials to evolve their roadmap, through a test & learn approach.

Kering has partnered with Fashion For Good since 2017. Fashion For Good scouts innovation all along the supply chain (from sourcing of materials to product end of life) and proposes pilots to test these innovations to its partners, as to help the transformation of the textile industry. This enables the group to be involved at the top of the production line (supply chain), materials and techniques but also the recommerce ecosystem to make fashion more sustainable.

Leather has a specific positioning in the materials space

Leather is viewed as a by-product of human food and meat production and should therefore always be around. Moreover, due to its very specific characteristics, leather is hard to replicate and that is why Kering is not looking for a pure leather equivalent replacement but rather for new materials for which the group can develop specific products. Kering's diverse brands and consumer styles enable it to experience new materials across the platform. For example, Balenciaga's clients have a more edgy style and are keen on trying new materials. Gucci consumers are also in demand for alternative, sustainable materials.

Investment rationale and length

At this point, investment in new materials is at a similar development point as pharma: huge investments are needed for uncertain returns. However, through its diversified investments, Kering is exposed to various maturity timelines, with mycelium being advanced, now facing the scale challenge but also closer to cost parity. In the meantime, lab grown leather is still facing technological challenges, with very small batches being produced and the scale issue a key question mark, not to mention the fact that it is 10x more expensive than mycelium.

Case Study: SQIM

Founded in 2015, SQIM manufactures a wide set of mycelium-based home furnishing and design products which started with acoustic panels and now includes leather alternatives. The company has raised EUR1.1m since inception.

We had a conversation with Maurizio Montalti, Co-founder & Chief Mycelium Officer.

Effectively marketed materials and products from the mycelium-based technology platform

Since its foundation in 2015, SQIM has been committed to scaling up fermentation processes harnessing the power of fungal mycelium as the ultimate platform technology, to obtain innovative materials and products that can effectively compete on the market. SQIM's processes are fully circular and start from the uptake and consequent valorisation of organic residues and low-value feedstocks from other value chains (e.g., agro-industry, manufacturing, etc.). Over time, and thanks to its Advanced R&D Team, the company has positioned itself at the forefront of the field in mastering mycelium-based technologies, while progressively learning about interactions between fungal strains, feedstocks, and overall environmental conditions, to obtain materials with specific techno-physical properties.

Vast set of opportunities

Over time, SQIM has created a very rich proprietary fungal bank, with over 300 strains collected and thoroughly studied, representing an essential part of its expertise in the space, while enabling the company to explore, develop and deliver a wide range of opportunities. SQIM entered the market in 2019 with products dedicated to interior architecture, such as acoustic and decorative wall/ceiling tiles, as well as resilient flooring solutions. At the same time, it developed new proprietary fermentation-based processes for products dedicated to Fashion, Automotive, etc., which started penetrating the market more recently, in 2022. With its constant technological developments, SQIM currently serves its two distinct brands: mogu™ and ephea™, while industrialising their nature-based technologies for reaching full commercial scale, and continuing to work with a large array of prestigious partners and customers, to introduce increasingly large and meaningful quantities of responsible products to the market that could make a real difference, primarily focusing on leather-goods and ready-to-wear, though already working in automotive, furniture, interior, etc. too.

A clear roadmap

SQIM's partnership with Kering started several years ago and was publicly announced at the same time as the launch of Balenciaga's long coat made out of ephea™, which was first released in March 2022 at Paris Fashion Week, to then become commercially available in selected global stores in autumn 2022. Despite being a new class of products on their own (i.e., not meant as "replacements") ephea™ materials can compete with premium leather from both a techno-physical, and a pricing perspective. SQIM currently operates pilot plants characterised by extremely high yields, and will be soon shifting to semi-automatised demo facilities that have been already designed and will start being deployed in the short term. The demos will allow the company to generate an increase in production volumes equal to at least 20x the quantities delivered by current pilots, while highly optimising the nature of the related processes, maximising quality, and consistently reducing costs and pricing. After full validation of the demos, SQIM will create its first full-scale commercial plants over the following three/four years, to help achieve the maximum positive impact possible, while continuing to develop and introduce innovative technologies and products that can contribute positively to establishing new productive standards working in full resonance with the rhythms of the greater ecosystem.

Case Study: VitroLabs

VitroLabs is an American biomaterials company which creates leather without harming animals, using a cultivated tissue process. The company was founded in 2016 and has raised EUR46.9m since inception.

We had a conversation with Ingvar Helgason, Co-Founder and CEO and Scott Packard, CFO.

Rooted in fashion, supported by science

After seven years running his own fashion brand, Ingvar Helgason realised that fashion does not need more new sustainable materials, but an increased supply of existing ones, such as leather. That's how VitroLabs was born. Through tissue engineering, the company replicates calf skin and produces a pure leather, free from any excess hair or skin. This leather then just needs to be tanned by the client to obtain a result similar to traditional calf skins. Starting with calf, this process could then be expanded into other animal cells such as crocodile, ostrich or sheep, which are covered by the patent. From only small pieces of leather originally, VitroLabs is now able to produce enough skin for a bag. Manufacturing capacities are the only limit to producing larger skin for wider, larger applications.

Starting with the highest set of standards

Luxury house Kering is partnering with VitroLabs as part of its search for sustainable materials and reducing its environmental footprint (80% coming from leather). Working with such demanding brands has led VitroLabs to develop products with the highest set of standards, to get the best quality products. Apart from enabling the group to reach price parity faster, this also sets it on a sound track when developing products with a lower set of standards, as it is easier to remove requirements than add them. VitroLabs' leather has become so popular that demand is now outstripping production, enabling it to choose its partners strategically. In the medium term, the group would like to expand into European fashion, and automotive in the US, but is not ruling out any opportunities at this point.

With no regulatory constraints

Contrary to cultivated meat, there are only a few players in the cultivated leather space, which leaves plenty of room for VitroLabs to capture the 23bn sqft of leather used every year in the industry! Moreover, development of cultivated leather is easier due to the limited regulatory burden, and even a favourable regulatory environment with the implementation of the Digital Product Passport in the EU from 2024 which will foster the need for transparent supply chains and act as a positive catalyst for VitroLabs.

Key challenge in labelling

Consumer acceptance will rely mostly on the product's labelling and its branding as leather. VitroLabs has Kering's backing on the "leather" name, which is a positive signal for investors and authorities. The scent and aspect are mostly dealt with during the tanning process and are therefore not a key issue in cultivated leather.

FIG 48: REGULATION IN KEY REGIONS

	Fermentation / Precision Fermentation	Mycelium Solutions	Cultivated Meat
Europe *European Food Safety Agency*	Pre-market approval for all-fermentation derived solutions. When the product is non-GMO and was consumed before 1997, EFSA assessment is sufficient. In every other cases, EU members need to approve through the Novel Food Framework before there can be EFSA review.	Mycelium derived solutions are considered as Novel Foods. Some of them, if they comply with the specific use conditions will be authorized Novel foods. Other (new or modified molecular structure) will need Novel Food approval similarly to the other two categories.	Still waiting for a precedent. Falls under the Novel Food regulation where the EFSA has to do a careful review of the subject. Shows it's more and more open to the products (date/statements) and waiting for dossiers to be submitted.
Israel *National Food Service*	Falls under the Novel Food regulation and the NFS must ensure quality, safety and authenticity of the product. Remilk was the first product allowed in 2023.	Likely to fall under the Novel Food regulation unless it was consumed before 2006. Quorn is allowed in Israel and regulation is likely to be softer compared to Fermentation and cultivated products.	Current regulatory status: Falls under the Novel Food regulation and the NFS has to ensure quality, safety and authenticity of the product. Collaborates with Ministries of Agriculture & Rural Development, Environmental Protection and Economy on cell-based products.
United Kingdom *UK Food Standard Agency*	The UK has retained the EU Novel Food regulation but from December 2022 started a review of the regulation which might lead to changes and a more favorable environment.	Quorn is allowed in the UK, and assuming there hasn't been genetical modification to the fungi streams, it's theoretically approved.	Aligned with European Union's guidance.
United States *US Department of Agriculture* *US Food & Drug Administration*	Two pathways: • Food Additive Petition (involved FDA consultation, petition to the agency for regulation issuance) • GRAS (Generally Regarded As Safe) submission to a panel of experts. A "no question" letter is needed.	Two pathways: • Food Additive Petition (involved FDA consultation, petition to the agency for regulation issuance) • GRAS (Generally Regarded As Safe) submission to a panel of experts. A "no question" letter is needed.	Pre-market consultation with the FDA on the processes used, then FDA initiates production inspections. Additional step for developers of cultivated food derived from livestock, poultry and siluriform: application to USDA-FSIS grand of inspection
Singapore *Singapore Food Agency*	Novel Food products are subject to premarket authorization. SFA has worked on providing enhanced guidance on information required. An early contact for R&D and commercialization has to be established with the agency.	New foods from fermentation are considered as Novel food and require SFA approval after reviewing the safety assessment of the products.	Novel Food Framework established in 2019: companies are required to conduct and submit safety assessment for SFA's review before allowed to sell. Accepts assessment reports by authorities from some foreign countries provided they are in conformity with reference documents from the USA, EFSA or Food & Agriculture Organisation / World Health Organisation.

*Source: Stifel**

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Agronutris Private Placement & Debt Financing € 100 000 000 *September 2021* *Sole Financial Advisor*	PROTIX Private Placement €50 000 000 *February 2022* *Sole Financial Advisor*	PROLUPIN Private Placement Undisclosed *March 2020* *Sole Financial Adviser*	avantium Publicly Marketed Follow-On Offering EURONEXT € 45 000 000 *April 2022* *Joint Global Coordinator & Joint Bookrunner*	SHARK SOLUTIONS Private Placement Investment Managers BLUE € 20 000 000 *September 2022* *Financial Advisor*	WAGA ENERGY Strategic Investments Vitol CMA CGM VIVA & Initial Public Offering EURONEXT € 126 000 000 *October 2021* *Sole Financial Advisor, Sole Global Coordinator & Joint Bookrunner*

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