NEW FOOD FRONTIERS

Realizing the promise of alternative proteins

Including international survey of **1,000+** chefs

GEA

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Promoting new food technologies from around the world.

The way we produce food is changing before our eyes.

Dining on alternative proteins?

Here's what chefs say about working with proteins derived from plants, fungi, cultivated cells ... and insects.

Improving both the quality and quantity of alternative proteins will be key to unlocking their potential.

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DEAR READER,

Food not only lends flavor to the world around us, it is also an important part of who we are as individuals and societies. It defines us and binds us together. A culture's cuisine embodies its rich traditions and diversity. It helps strengthen communities and reinforces bonds between families, friends and colleagues. When abroad, the right dish can help us feel at home. And when we enjoy the food of entirely different cultures, it brings the world together.

Just as individuals and societies evolve, so too does food. Today, we are experiencing a major transformation in the culinary world. Driven by the changing awareness for nutrition and rising environmental concerns, lower-impact alternatives to conventional meat, seafood, eggs and dairy are gaining ground around the globe. More and more restaurants are serving plant-based burgers and dairy alternatives. In many supermarkets we see a growing variety of foods that complement traditional meat or other animal products. Meanwhile, innovative technologies in fermentation and tissue engineering are rapidly proving their viability and gearing up to revolutionize how we produce meat, seafood and dairy in the future.

At GEA, we call this growing array of alternative proteins *new food*. As a leading provider of machines, know-how and full process lines to the global food and beverage industry, we are at the front lines of today's new food transformation. Our in-depth expertise is helping both startups and established companies bring new foods to market by enabling the development and commercial-scale production of alternative protein products. This puts us at the center of a defining moment that will very likely shape the future of nutrition.

Our goal with this *New Food Frontiers* report is to share our perspective from this unique position and contribute to the growing body of insight and knowledge around alternative proteins. The report features research, reporting as well as interviews with leading minds in the new food industry. It spans a broad spectrum, shedding light on today's trend towards alternative proteins, how technology is helping accelerate their development, and where barriers exist in realizing their full potential.

As a unique feature of the report, we are excited to present the results of an exclusive survey of chefs from around the world. Chefs are opinion leaders when it comes to food. They drive key trends, shape consumer demand and influence what will be served in many homes. We consider their perspective to be vital for an informed, well-rounded understanding of the new food landscape. Indeed, the survey suggests chefs are at the vanguard of today's food transition.

I hope you enjoy reading this report, and I hope it helps illuminate a path towards a world in which sustainability is the key food imperative. It is certainly a journey worth taking. Alternative proteins hold the promise of helping feed a growing population using fewer resources. As such, they can play an essential role in making our food system more sustainable and reliable. That is what gives new foods their particularly bright flavor.

Sincerely,

Stefan Klebert
CEO, GEA Group

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Alternative proteins can play an essential role in making our food system more sustainable and reliable.

EXECUTIVE SUMMARY

An overview of the main points covered in this report

Making our food system more sustainable
As the world population surges towards a projected 10 billion by 2050, the demand for meat and other protein-rich foods is accelerating. Animal agriculture is responding with advances in digitalization, productivity and overall efficiency to help meet this growing demand. But to feed the world more sustainably in the future, we will have to rely much more on lower-impact forms of protein. Fortunately, reinforcements have arrived. Alternatives to conventional meat, fish, eggs and dairy are already serving an increasing share of the world's protein needs with less impact on climate and the environment. These alternative proteins – or new food, as we call these products and ingredients at GEA – are the subject of this report. They represent a unique opportunity to set the world's food system on a more sustainable, climate-friendly path.

New food is advancing fast
Readers less familiar with alternative proteins might be surprised to learn how mature the industry already is. Today's **plant-based** meat and dairy alternatives are well into the next phase of their evolution. Rapid advances in their taste, texture and overall meatiness have pushed them into the mainstream in key markets. **Fermentation-based** processes are accelerating the marketability and uptake of alternative proteins by producing large quantities of protein as well as a long list of useful natural products, such as vitamins, enzymes, flavoring agents, pigments and fats. With the potential to revolutionize the meat industry, **cultivated meat** has gone from the realm of pure theory to near commercial viability in the last decade alone. According to the Good Food Institute (GFI), more than 100 companies worldwide are pursuing this opportunity as of 2021 – from startups to major food-industry players. At the same time, **hybrid products** are being developed that combine plant-based, fermentation-enabled and cell-based proteins, speeding up the process and further improving quality. Even **insect-based** proteins, long popular in many parts of the world, are now also making their way West because of their undeniable benefits as a low-impact, high-efficiency provider of protein.

10 bn
World population in 2050, as projected by the United Nations.

Consumers are hopping aboard
Consumers are increasingly attracted to the environmental benefits and ethical aspects of alternative proteins. A growing body of international surveys and academic studies reveals a high level of interest and openness on the part of consumers around the world. More than half of the 3,700+ consumers taking part in a 2022 survey by impact investor Blue Horizon and Boston Consulting Group (BCG) consider themselves at least occasional users of alternative proteins. Some 31 percent feel that climate concerns – and the ability to have a significant positive impact on the climate – are a primary reason for fully switching to alternative proteins. According to the GFI's recent Europe survey, between one-third and two-thirds of consumers in several major European countries expressed their willingness to buy cultivated meat when it becomes available on the market. The younger generation, especially, increasingly recognizes food as a high-impact choice to affect positive change.

Chefs are transitioning
The GEA Chef Survey on New Food revealed that chefs have already begun making the transition to alternative proteins (see p. 26). The large majority are familiar with the various types of alternative proteins and significant numbers are using them in their kitchens today. Well over a third, for example, use meat and dairy alternatives in their daily work to a high extent. Cultivated meat is not yet commercially available to most chefs, but 41 percent indicate that they already know a lot about it. Half of chefs predict a strong increase in demand for plant-based proteins in the next 10 years, and nearly half (45%) predict strong growth in demand for cultivated cell-based proteins among their restaurant guests. Overall, the survey data suggest that many chefs are keenly aware that cultured meat and similar products could redefine how people eat in the future, and see the need to keep up with such a fundamental trend.

Investors and governments are moving
In a joint 2021 report, BCG and Blue Horizon estimate that alternative protein will capture at least 11 percent of the gargantuan global protein market by 2035 (and possibly up to 22%), with revenues of some US$290 billion across the value chain. Investors have taken note. The GFI reports that the flow of investment capital into alternative proteins accelerated at an annual rate of 124 percent from 2019 through 2021. Governments are mobilizing as well. Just five years ago, state funding for alternative protein R&D was roughly zero; today that total exceeds US$300 million from more than a dozen countries. In addition, governments are integrating alternative proteins into their multi-year national food and agriculture plans, and generally recognizing the potential of alternative proteins to meet national policy goals with respect to climate, public health, biodiversity and economic development. How governments around the world opt to regulate alternative proteins will play a vital role in their future development. Effective regulation will clear the path to market while making sure consumers continue to trust in product safety and choose what's best for them based on clear labeling.

35%
of consumers already consider themselves frequent users of alternative proteins.

Technology is key
The optimism and momentum building behind alternative proteins is largely due to tremendous progress in technology and production know-how over the last several years. At the same time, technology and industrial processes represent a potential bottleneck moving forward. Alternative proteins will have to be produced on a massive scale to become affordable, which is why the transition to industrial-scale production is in many ways the most critical next phase.

Some of the key steps towards industrial scale production include:
- Plant protein crops engineered for enhanced taste and protein content
- Microorganisms developed for high-efficiency conversion of feedstock into desired products
- Cell lines for cultivation that yield the best, most nutritious end product and in the greatest quantities
- Inexpensive, non-animal cell culture media
- Industrial processes that optimize protein extraction and effectively leverage byproducts
- Smart bioreactors that cater to the needs of cell cultures or microorganisms

Chances are good
Fulfilling the promise of alternative proteins will require continued progress on a number of different fronts. While much work remains to be done, the research and conversations behind this report suggest a certain inevitability to the forward march of new foods. The question is not whether alternative proteins will transform the food world, but when. In fact, new food is just one part of a fundamental shift towards producing and consuming everyday products in vastly more sustainable ways. The technologies behind alternative proteins have game-changing applications not just in food, but in multiple industries, including healthcare. This strongly suggests that alternative proteins have a good chance of realizing their promise as a reliable, low-impact source of nutrition for billions of people.

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While much work remains to be done before alternative proteins can realize their true potential, the research and conversations behind this report suggest a certain inevitability to the forward march of new foods.

KEY TAKEAWAYS

1

A broad shift to alternative proteins can make our food systems more reliable and sustainable.

Even with animal agriculture advancing in terms of productivity and overall efficiency, more help will be needed to meet the protein demands of a growing population even more sustainably. Lower-impact alternatives to conventional meat, fish, eggs and dairy cannot only help feed the world, but also address multiple global challenges at once – from food security and climate change, to sustainable economic development.

2

Alternative proteins are already transforming how we produce food.

Major advances in the taste and texture of plant-based proteins have propelled these formerly niche meatless products into the mainstream in key markets. Precision fermentation is harnessing the power of microorganisms to enhance the quality and accelerate the uptake of alternative proteins. Cultivated meat – biologically identical to conventional meat, but significantly more sustainable – is advancing rapidly and holds tremendous potential to reshape food in the long run.

3

Food professionals worldwide are embracing alternative proteins.

According to the GEA Chef Survey, some 90 percent of chefs already use meat and dairy alternatives in their daily work to some extent, with well over a third using them to a high extent. Roughly 90 percent of chefs also report an increase in demand for alternative proteins among their restaurant guests. Looking ahead, 66 percent of chefs anticipate that at least one quarter of all food – if not more – will be made with alternative proteins by 2040.

4

Consumers are open to alternative proteins and already driving the change.

While many consumers want to see further improvements in taste and price, a growing body of international surveys indicate that consumers in many regions are eager to buy plant-based alternatives and receptive to trying cell-based meat. This is due in large part to concerns about the impact of conventional meat production on the climate, environment and animal welfare.

5

Technological innovation will be key to producing alternative proteins at scale.

To realize their promise, alternative proteins must become plentiful enough in supply so that conventional meat consumption can actually decrease, even as global demand for protein-rich foods grows. For many of the most promising new foods, the next big test will be making the jump from the lab to large-scale production using tailored cutting-edge technologies and industrial processes.

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THE PROMISE OF NEW FOOD

An introduction to alternative proteins and why we need them

The world is rethinking energy, gradually transitioning to greener solutions to power everything from cars to factories to devices. And with the global population projected to grow to nearly 10 billion by 2050, we're also having to rethink how we power ourselves.

For decades, industrial scale agriculture has provided a reliable, affordable source of energy for billions of humans around the world. But as with fossil fuels, the true costs of conventional food production are becoming clear. Producing a single kilogram of beef, for example, requires well over 300 square meters of land, and generates an average of nearly 100 kg of CO_2e. In 2020, the world consumed 60 billion kg of beef. Meanwhile the global middle class is projected to grow to over 5 billion by 2030, which means the world's appetite for protein – particularly meat – is growing faster than the population itself. Simply expanding today's agricultural production capacity to meet this demand would mean severe environmental and societal consequences.

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While fermentation has a long history of using microbes to enhance the nutritional profile of our foods, it is finding new applications in the alternative protein space.

The good news is that the way we produce food, particularly protein, is already changing before our eyes. While electric cars and solar panels grab the headlines, the alternative protein industry is growing rapidly, with innovative new foods quietly gaining space on supermarket shelves and restaurant menus.

Next-gen protein

The goal of alternative proteins – including plant-, cell- and insect-based proteins – is to provide sustainable, healthy, ethical alternatives to conventional meat, fish, eggs and dairy products. And their time has come. More and more consumers view the production of these conventional foods as not sustainable enough. At the same time, individuals are recognizing that their own food choices can have a significant positive impact on the environment, their own health and the welfare of animals. This shift in consumer attitudes – combined with advances in technology – is the fundamental driver inspiring startups, established companies and investors to enter an alternative-protein market projected to reach US$290 billion by 2035.

Power plants

On the front lines of today's protein transformation are plant-based proteins. Classics like tofu or tempeh have proven their value for millennia, and for decades health- and planet-conscious consumers have enjoyed access to all manner of non-dairy milks, veggie burgers and other curious meatless meats. But today's plant-based proteins are well into the next phase of their evolution. Powered by advances in biotechnology and growing interest on the part of consumers and investors, food companies large and small are achieving rapid advances in the taste, texture and overall meatiness of plant-based meat alternatives. And thanks to improved scalability, they are already widely available today in supermarkets and take-out lines around the world.

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The alternative protein industry is growing rapidly, with innovative new foods quietly gaining space on supermarket shelves and restaurant menus.

US$290 bn

Projected value of global alternative protein market in 2035.

Fermenters as farms

While fermentation has a long history of using microbes to enhance the nutritional profile, digestibility and shelf life of our foods – from tempeh to kimchi, wine to cheese, yogurt to sauerkraut – it is finding new applications in the alternative protein space. Traditional fermentation, as it turns out, can also be used to enhance various aspects of plant-based proteins such as flavor and nutritional function. And two newer forms of this ancient art and science – biomass fermentation and precision fermentation – are proving key to getting new proteins to market.

Biomass fermentation delivers on scale. By taking advantage of the fast growth and high protein content of microorganisms such as yeast, filamentous fungi and microalgae, biomass fermentation can produce large amounts of protein in a short amount of time. Mycoproteins harvested from fungi, for example, are used to produce several brands of meat substitute at scale that provide both protein and fiber without cholesterol or saturated fat. A model of resource efficiency, biomass fermentation can also be used to turn agricultural byproducts into nutritious food.

Today's most high-tech version of fermentation – precision fermentation – harnesses microbes to function as mini factories that can churn out a long list of useful natural products. The spectrum ranges from micro-ingredients like vitamins and fats to – and this is special for new food – large quantities of macro-ingredients like casein and beta-lactoglobulin. Already a mature technology used in a number of industries, precision fermentation has rapidly become key to enhancing the functionality and taste of plant-based proteins. Among the many applications: fats derived from yeast can be added to plant-based dairy for improved texture, fungal fats in plant-based meat mimic the way animal fats release flavor, and animal-free omega-3 fats can be added to alternative meat and seafood products as a customized health boost.

All three types of fermentation offer opportunities to accelerate the marketability and uptake of alternative proteins. According to the Good Food Institute, a nonprofit working to accelerate alternative protein innovation, the number of companies around the world engaged in fermentation-enabled proteins grew more than tenfold – from 8 to 88 – between 2013 and 2021.

Cultivated meat

The most innovative and arguably most promising alternative protein, cultivated meat is by far the youngest. It was only in 2013 that Maastricht University's Dr. Mark Post proved the concept of his in vitro burger, which cost roughly US$325,000 to build. But by 2020 cultured meat – lab-grown chicken – made its restaurant debut in Singapore at a price much closer to conventional meat. Singularity University founder Peter H. Diamandis called the breakthrough a "moonshot."

Cultivated (or cell-based) meat is not meat substitute; it is actual meat, produced by actual animal cells outside the animal instead of inside. Location is everything, and this key difference means potentially big gains in sustainability over conventional animal agriculture. As of 2021, investors have responded with some half a billion U.S. dollars in financial backing for more

Alternative protein technologies can – and must – work together to achieve the economies of scale and level of quality necessary for these new foods to succeed.

than 60 companies along the cultivated meat value chain. But even with real animal cells doing the work, it remains a very complex task to replicate the color, mouthfeel and taste of conventionally produced meat in the lab.

Achieving scalable production of cultivated meat may be the biggest hurdle on the alternative protein landscape. Large-scale production will require large-scale acquisition or derivation of the necessary stem cells, vast amounts of growth promoting cell culture media, and affordable scaffolding materials needed to build meat-like structure and texture – to name three of the main technical challenges. As with plant-based proteins, precision fermentation can play a key supporting role here – by providing an efficient way to produce the nutrients and growth factors needed for cell culture media and by generating proteins suitable for scaffolding, such as collagen or fibronectin. This is just one example of how alternative protein technologies can – and must – work together to achieve the economies of scale and level of quality necessary for these new foods to succeed.

Grassroots appeal

To be sure, alternative proteins are up against huge advantages enjoyed by the incumbent meat industry. And given that demand for animal meat is expected to outpace population growth through 2050, the odds might seem stacked. Today's lack of scalable supply means that many of these new proteins cannot yet meet the volume requirements of large food companies. To have a significant impact, supplies of alternative proteins will need to increase dramatically. Despite its promise, cultivated meat is still in its infancy – yet to prove its scalability or even acceptance among consumers. While plant-based meat alternatives are approaching parity with conventional meat in taste, texture and price – and are widely available today in stores and takeout counters around the world – their market share of total retail meat in the U.S. was just 1.4 percent as of 2020.

But times are changing fast. There is a groundswell of interest in healthier, lower impact eating – an openness among mainstream consumers to flexitarian diets with more plant-based foods and less meat. According to the Good Food Institute, 98 percent of Americans who buy plant-based meat also purchase conventional meat – a strong indication that plant-based has gone mainstream and that uptake will accelerate as the availability and quality of alternative proteins continues to increase. Plant-based meat sales in the U.S. grew 19 percent from 2018 to 2019, followed by 45 percent growth from 2019 to 2020. By 2020, the U.S. retail market for plant-based foods reached US$7 billion, with sales of plant-based foods growing nearly 2.5 times faster than total food sales from 2018 to 2020. While sales of plant-based meats cooled in 2021-22, and growth is likely to be non-linear moving forward, the longer-term outlook remains strong.

In a joint report, Boston Consulting Group (BCG) and impact investor Blue Horizon estimate that alternative proteins could capture between 11 percent and a whopping 22 percent of the world's protein market by 2035, depending on how quickly price, quality and production efficiency can be optimized, and whether or not regulators get in the game to help farmers transition from animals to alternative protein. For now, BCG predicts alt-protein revenues of US$290 billion across the value chain by 2035. Given the size of the pie, it's no surprise that more and more established food companies are joining the myriad startups pursuing the promise of new proteins.

The impact of your dish

The protein transformation represents not only a major business opportunity, but also a major lever in the effort to reduce the environmental footprint of human activity. Consider food's impact on greenhouse gas (GHG) emissions alone: The food system as a whole is responsible for roughly one-quarter of global GHG emissions, with the market for animal-based products accounting for some 15 percent of that. For the individual consumer, this means that even seemingly small actions can have a measurable impact.

And consumers are motivated. An international consumer survey conducted by BCG and Blue Horizon in early 2022 revealed that 31 percent of consumers consider climate – and the ability to have a significant positive impact on climate – to be a primary reason for fully switching to alternative proteins. The survey also pointed to a 100 percent "potential increase in exclusive or near-exclusive" use of alternative proteins among consumers if their remaining concerns about taste, nutrition, health and safety can be resolved.

These numbers indicate a remarkable openness and willingness to change among consumers, and strongly suggest an alternative protein wave with the power to significantly disrupt the food industry. For today's food companies, being equally open and willing to change will be key to catching the wave.

~25%

of global GHG emissions can be attributed to the world's food systems.

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THE DOUBLE **POSITIVE**

Dr. Friederike Grosse-Holz, Director at impact investor Blue Horizon, talks about why sustainable food is such a compelling new field, what it will take to bring alternative proteins to market faster, and how regulators can help.

Dr. Friederike Grosse-Holz, Blue Horizon

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We have an amazing opportunity to reduce emissions by transforming the food system. Alternative protein technologies have matured to the point where they can now be scaled.

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At this point, more growth capital needs to flow into [the alternative protein] sector to facilitate the scale-up of technologies.

Tell us about impact investing and how Blue Horizon is embracing it.
At Blue Horizon our goal is to achieve a double positive, which means making a return on investment, as well as a tangible positive impact. Sustainable food is a great way to achieve this double positive: the more revenue you generate, the more impact you have. Every alternative burger or alternative egg purchased by a consumer has both a positive impact and creates returns for this sector.

In terms of impact, we look at three aspects: human, animal and planetary impact. We are also focused on ways to quantify impact in dollar terms, value the investment on the impact and return side, and maximize the potential for a double positive across returns and impact. For example, when it comes to the planetary impact of the protein transformation, we look at how much emissions are avoided by making the transition to plant-based food. We then translate these emissions into a dollar value using a carbon price set by the market, generating a financial metric: impact on capital employed, IoCE. IoCE works just like a financial return on capital employed (RoCE), and can be determined not just for planetary, but also human and animal impact. Metrics like IoCE™ allow us to use similar tools to quantify and manage impact and returns.

We use this method across our entire investment process. Similarly, when working with a portfolio company, we co-develop financial- and impact KPIs.

Is now the right time to invest in the alternative protein market?
Absolutely. The underlying drivers of the protein transformation have only gotten stronger. We are all aware of the climate crisis we face as a species; this is a global problem that we need to solve – and food is a major contributor, unfortunately. Food systems account for 24 percent of global annual emissions, second only to energy. In fact, food-related emissions have a 70 percent greater impact than the transport emissions generated by all cars, airplanes, trains and ships globally. That means we have an amazing opportunity to reduce emissions by transforming the food system.

So now is a very interesting time. Alternative protein technologies have matured to the point where they can now be scaled, although the sector has yet to take off as much as we believe it can. Product market fit is proven and now being improved further with cleaner labels and a more diverse array of products. So now it's about scaling up, so these products become mainstream. At this point, more growth capital needs to flow into this sector to facilitate the scale-up of technologies.

Which countries are furthest on this journey?
Key centers have emerged where the sector is more commercially mature. A lot of startup activity is happening in the U.S. and Israel, for example. Singapore is pushing for greater food sovereignty and has championed the shift towards alternative proteins for the last several years. Generally, the very large consumer base in Asia Pacific is traditionally more familiar with "first generation" alternative protein products like plant-based milk. We are keeping a very close eye on this region, and Blue Horizon recently made its first investments in India. Another interesting region is Europe, where consumers are very concerned about the environment. France has an active startup base, for example.

But really, we see fascinating technologies coming from every corner of the world, often stemming from different motivations and cultural preferences – just like the different flavors found in food. Local innovation is fundamental since cuisine is shaped by cultural norms. We need people developing products based on an understanding of what their neighbors want.

> *We see fascinating technologies coming from every corner of the world, often stemming from different motivations and cultural preferences – just like the different flavors found in food.*

What is the role of regulation and how will it need to evolve?
Regulation plays an important role in enabling a smooth transition to alternative proteins. In our view, regulators will make this transition feasible, especially for the people who have to do the work, namely farmers. As we grapple with the financial side of this transformation, we cannot forget the farmers. They are the bedrock of our food system, and for them, the shift will be doubly challenging given the already slim margins for agricultural products. Historically, farmers have received subsidies that favor animal agriculture, so upfront investment is needed to help them reshape their operations.

Regulators are also key to making sure consumers continue to trust in the safety of the food they buy and can choose what's best for them based on clear labelling. So, if companies want to bring innovation to consumers in a timely fashion, open and collaborative communication between regulators and companies is critical.

How do you identify the companies you invest in?
Blue Horizon has deep expertise and technical know-how in the sustainable food sector. Based on this, we built a proprietary quantified market model (QMM). Our QMM maps where value creation occurs along the food value chain – and which technologies could be game changers for the food system. We continuously update and refine this model with market data, expert discussions and technical research. This provides us with key insights on which technologies will be most valuable once scaled. We focus our deal sourcing on these value pools. We then look for strong teams who are ready to execute on their stated mission and who share our values.

How closely do you collaborate with companies after investing?
This varies and depends entirely on what is most valuable for the company. One thing we always do is work with our portfolio companies on impact and on financials, which most companies find very useful. For example, our quantitative impact reporting helps them tell their impact story in a concise, convincing way to their customers, partners, and employees. But there's a whole range of support we offer – everything from providing warm introductions to international retailers in our network, to giving feedback on their next pitch deck.

Looking at the entire field, where do you see the greatest potential going forward?
Moving forward, all types of alternative proteins – whether plant-based, cell-based or fermentation-based – will have to work together. Hybrid products are a good example of this; they will be key to getting alternative proteins to market sooner. We already see numerous hybrid products in the development stage incorporating a bit of cell-based technology to achieve specific mouthfeel and desired flavor. Nutrients such as B12 or omega-3 generated from cultivated cells can be added to plant-based products to boost their nutritional value. And we see hybrid products that combine fermentation-enabled and plant-based proteins. A notable example here are plant-based burgers which incorporate heme protein, like the Impossible burger. Another example is plant-based cheese fortified with casein, which confers the much-desired stretching and melting behavior of traditional cheeses. Hybrid products will enable fermentation and animal cell-based proteins to come to market much sooner than if they relied 100 percent on cultivated meat or 100 percent on fermentation-enabled product.

What key innovations would foster even greater uptake of alternative proteins?
One is the need for more bioreactors to scale up production processes. This would certainly help solve the massive bottlenecks on the fermentation side, where there is simply too little fermentation capacity.

Another barrier that is not often discussed is the shortage in human capabilities. We need more people who can design and operate plants that produce alternative proteins. At the moment, there are too few companies like GEA, who have the expertise required by this growing sector. A lot of companies today can make a very interesting product on the scale of 500 milliliters, but now face the challenge of scaling up to 500,000 liters. This requires a completely different skill set.

It's a situation that is ripe for more industry collaboration and an injection of growth-type capital, particularly where a technology is mostly de-risked and ready for scaling up. There are more and more of these kinds of opportunities emerging. And when leveraged, this will propel the industry to the next step and bring fermentation-enabled products, hybrid or purely fermentation-based, to the mass market.

Dr. Friederike Grosse-Holz

Scientific Director, Blue Horizon

As Scientific Director of the Blue Horizon Growth team since 2021, Friederike brings experience in both biotechnology and strategy consulting. After earning her doctorate in Plant Biotechnology from the University of Oxford, she joined the Boston Consulting Group, working across biopharma, biotech, energy and private equity for 3.5 years. Friederike maintains a strong network in the scientific community and is passionate about safeguarding humanity's long-term future. To this end, she co-authored work that informed the research agenda of Oxford's Global Priorities Institute and is an active member of the effective altruism community.

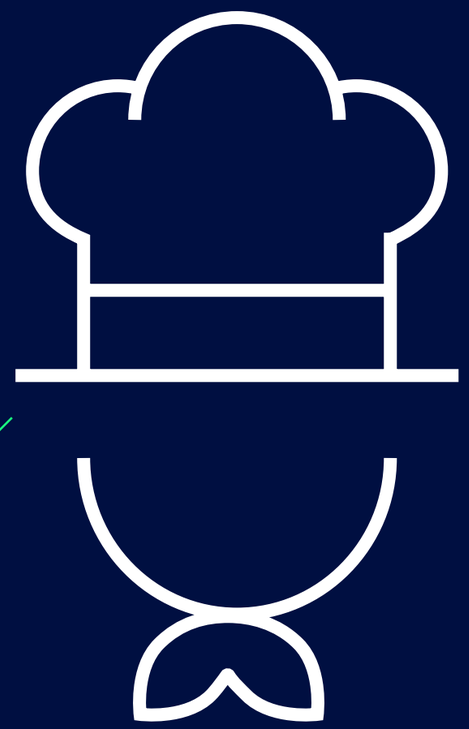
CHEFS WEIGH IN

GEA CHEF SURVEY ON NEW FOOD

Driven by technological progress and changing consumer demand, the rising popularity of alternative proteins in recent years is already impacting the culinary world. So how do chefs view this development? Are they embracing alternative proteins and helping drive their growth and popularity?

1,002

chefs around the globe were interviewed



92%

of chefs said they were familiar with plant-based food and beverages

The *GEA Chef Survey on New Food* considers the rise of alternative proteins through the eyes of some 1,000 chefs around the globe. Conducted in August 2022, the survey provides a variety of insights into how chefs are navigating the current food transformation. It sheds light on their familiarity and experience with new food products, the current demand among restaurant guests, and what chefs expect to see in the near future. The results help build a more nuanced understanding of the transition towards new food.

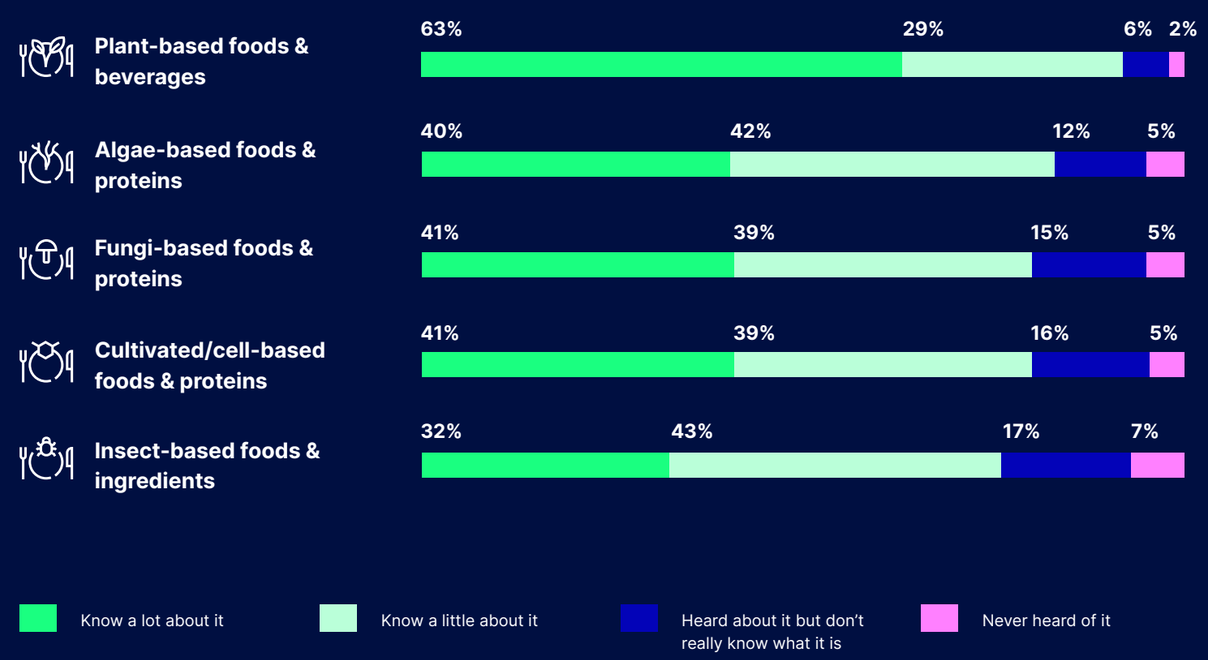
Interested and engaged

Considering that chefs not only earn their living via food but, in many cases, define themselves in terms of their devotion to food and culinary traditions, one might expect a healthy dose of skepticism when it comes to alternative proteins. Sure enough, our Chef Survey on New Food did uncover some skepticism among chefs: a few were dismissive, some had never heard of alternative proteins, others showed little interest in learning about them. But these were decidedly in the minority. In fact, the large majority of chefs surveyed are familiar with the various types of alternative proteins and already using them in their kitchens.

In the case of plant-based foods and beverages only 2 percent of chefs had "never heard" of them. Another 6 percent had heard about them but had no real knowledge of them. As depicted in Figure 1, the remaining 92 percent were familiar with plant-based foods and beverages, with a majority of these (63%) indicating that they know a lot about them. This is no huge surprise. Plant-based products like soy drinks and veggie burgers have been around for decades; tofu and tempeh for millennia.

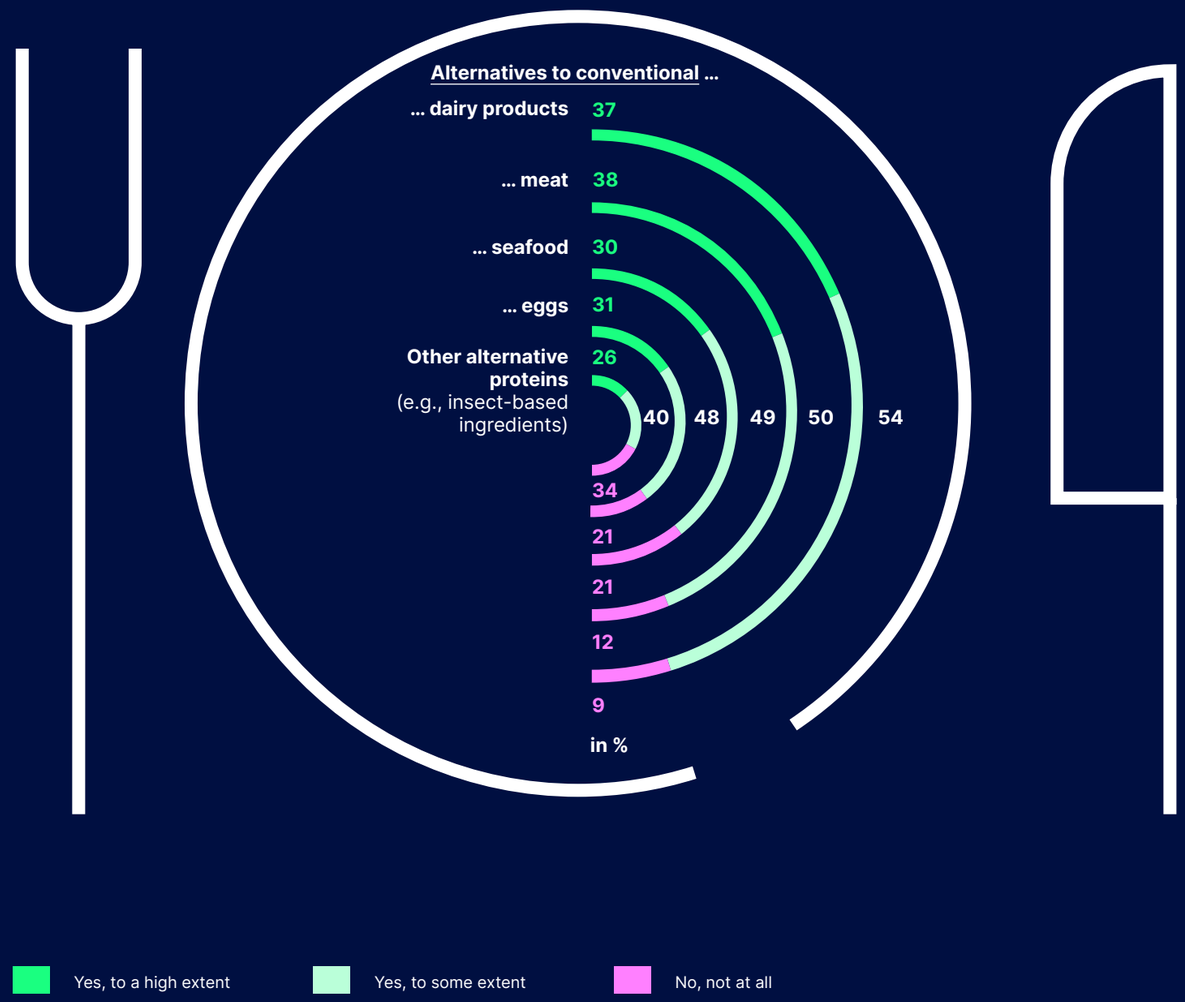
But even in the case of cultivated, cell-based proteins – the most novel of all alternative protein types – a full 80 percent of chefs said they were familiar with them. More specifically, 41 percent of chefs said they know a lot about cultivated, cell-based foods. This is remarkable given that cultured meat is in its infancy, a long way from large-scale production and availability. Yet the survey data suggest that many chefs are keenly aware that cultured meat and similar products might redefine how people will eat in future, and they see the need to closely observe and keep up with such a fundamental trend.

Fig. 1: How familiar are chefs with alternative proteins?



As depicted in Figure 2, most chefs are not only aware of the new food trend, but they are also helping drive it. Roughly 90 percent of chefs are already using meat and dairy alternatives in their daily work to at least some extent, with well over a third of chefs using them to a high extent. Use of seafood and egg alternatives is somewhat less prevalent, but here, too, some 30 percent of chefs are already using them to a high extent. If there is one message to take from the survey, it's that most chefs around the world are definitely not waiting around; they have begun making the transition to new foods.

Fig. 2: Do chefs use new food products in their restaurants?



These foods are very interesting. I wish they were more accessible to everyone because they are much better for both health and the environment.

Chef, Brazil

Customers want more

Clearly, the high level of awareness and use of alternative proteins by many chefs is partly due to their own professional interest; they want to be well-informed about food developments and stay on top of this growing trend. But as the survey clearly indicates, their interest is also due to rising customer demand. Their own guests, as well as restaurant goers in general, are increasingly asking for alternatives to conventional food. As shown in Figure 3, roughly 90 percent of chefs see increased demand among their restaurant customers for alternatives to conventional meat and dairy, with over 40 percent of chefs reporting a high degree of increased demand. The numbers on seafood and egg alternatives are once again slightly lower, but still indicative of significant growth in demand.

This is consistent with recent consumer feedback. A 2022 Blue Horizon/Boston Consulting Group survey of over 3,700 consumers worldwide found that more than half of them are occasional users of alternative proteins, 35 percent frequent users and some 13 percent "exclusive or near-exclusive" users. The Good Food Institute's Europe survey conducted in 2022 found that half of consumers in Spain and Italy already eat plant-based meat on a monthly basis, with 65 percent of Spaniards, 55 percent of Italians, 57 percent of Germans and a third of consumers in France indicating their willingness to buy cultivated meat when it becomes available on the market. Another recent study showed that 80 percent of UK and U.S. consumers were open to eating cultivated meat.

Fig. 3: Do chefs experience increased demand for new food from guests?

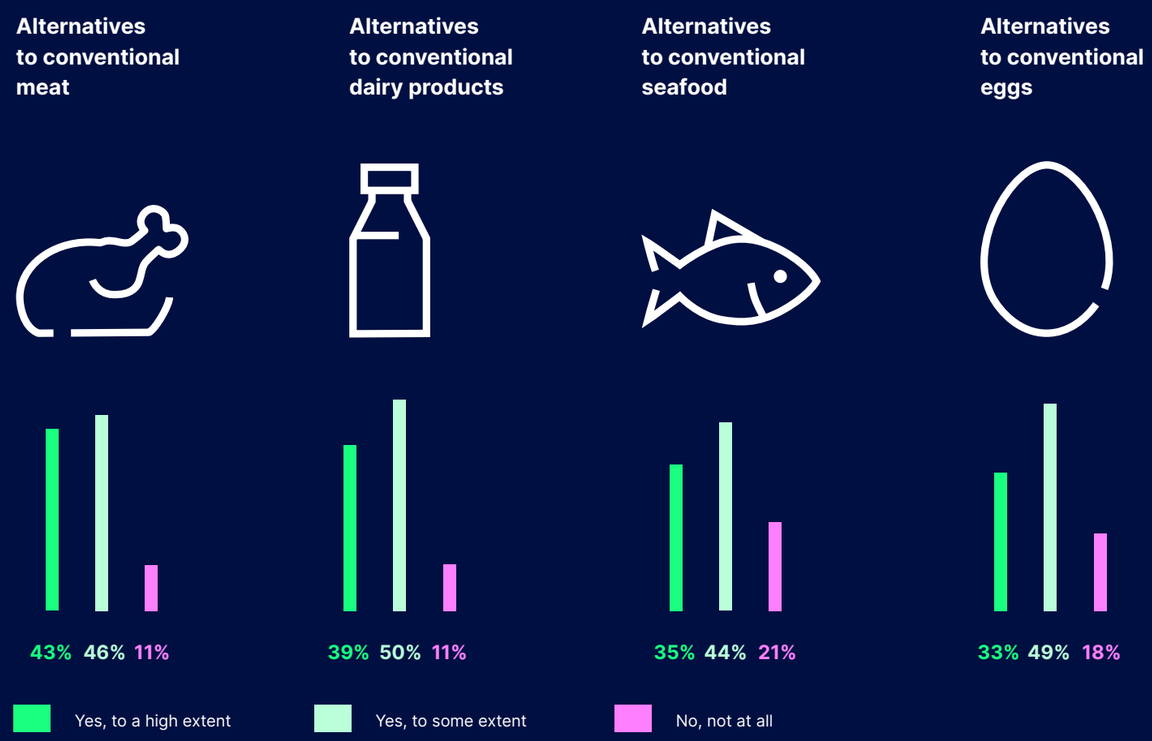
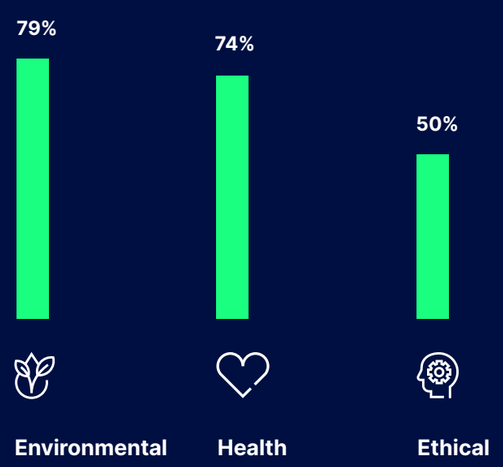


Fig. 4: What are the main drivers chefs see behind the increasing preference for alternatives to conventional food?



We chefs have an obligation to offer recipes with these new foods to raise awareness about the challenges we face in the world today. New foods can have a major impact on the environment, on health and on animal care. Our restaurant can contribute to educating customers as well as meeting their demands.

Chef, Brazil

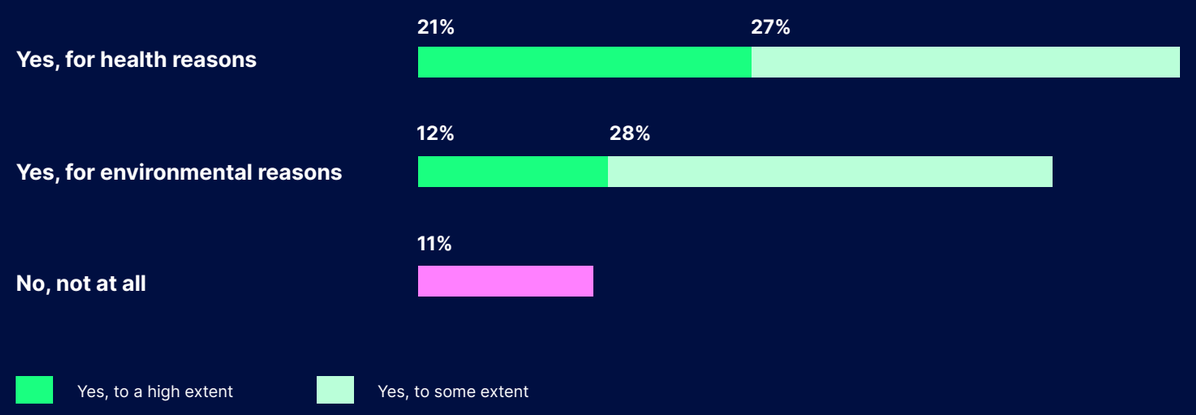
Key drivers

When asked about the primary drivers of growing demand for alternative proteins among restaurant guests, most chefs cited both health and environmental reasons. Some 79 percent of respondents believe that their customers are motivated by environmental concerns, while 74 percent indicated that health reasons are a motivating factor. Fewer chefs (50%) see ethical concerns, such as animal welfare, as a factor.

Chefs in the lead

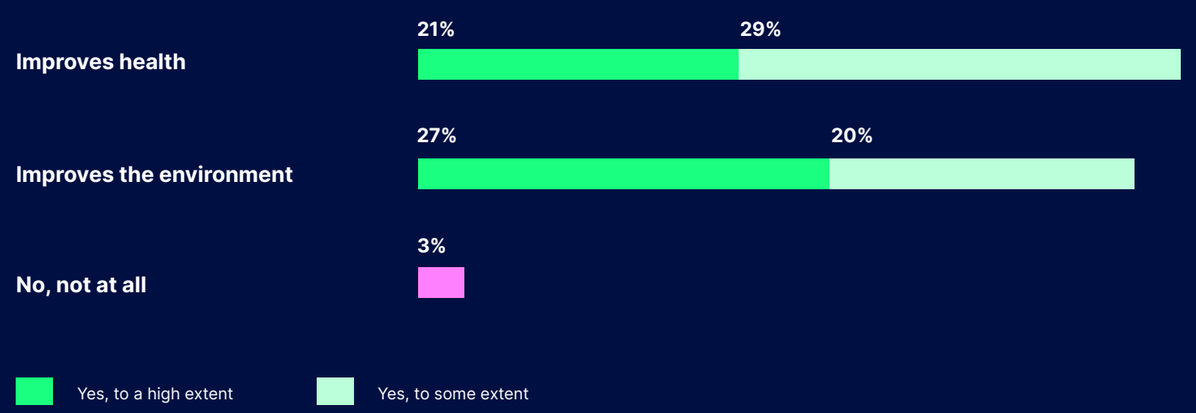
Three out of four chefs surveyed (75%) consider food in general to be a very important factor in human health, and just under two-thirds (62%) consider food a very important factor in environmental health. In addition, nearly half of chefs (48%) believe that new food alternatives can have a big impact on improving human or environmental health. So how do chefs view their own role in this context? The survey results indicate that many chefs and restaurants are mindful of their personal and professional responsibility to assume a leadership role. For starters, one-third (33%) are significantly reducing the amount of meat they themselves consume for health or environmental reasons. Some 15 percent are fully vegetarian or vegan. Nearly all (96%) say their restaurant is taking steps to lower its environmental impact, with 44 percent working actively ("to a great extent") on this front. And the majority of chefs (53%) feel that they themselves play a critical role in their guests' food choices – more so than social media, advertising, friends and family, influencers or food critics.

Fig. 5: Are chefs actively reducing their own meat consumption?



> *It's difficult to say what it will be like in 2040, but more and more people are paying attention to their diet and want to try to consume less meat or animal products.*
>
> **Chef, Germany**

Fig. 6: Do chefs view new food as a way to improve human health and the environment?



A look to the future

Chefs around the world clearly believe that the trend towards alternative proteins will continue to gain momentum in the years to come. Nearly 95 percent feel that their restaurant patrons will demand more plant-based proteins over the next decade, with half of chefs seeing a strong increase in demand over that time. The numbers are similar for cultivated, cell-based proteins, with 45 percent of chefs predicting strong growth in demand for them. Even for insect-based proteins and foods, 36 percent of chefs believe that their customers will demand considerably more of these over the next 10 years – a result driven mainly by chefs in Asia.

Nearly one-quarter of the chefs surveyed (23%) expect new food to constitute more than 50 percent of all food in 2040. An additional 43 percent of respondents believe that one-quarter to one-half of all food in 2040 will be made with new food products and ingredients. Taken together, this constitutes a remarkable outlook into the next decades. It suggests that many of the surveyed chefs, most of whom are younger than 40, view alternative proteins as a significant and increasingly essential part of their future jobs.

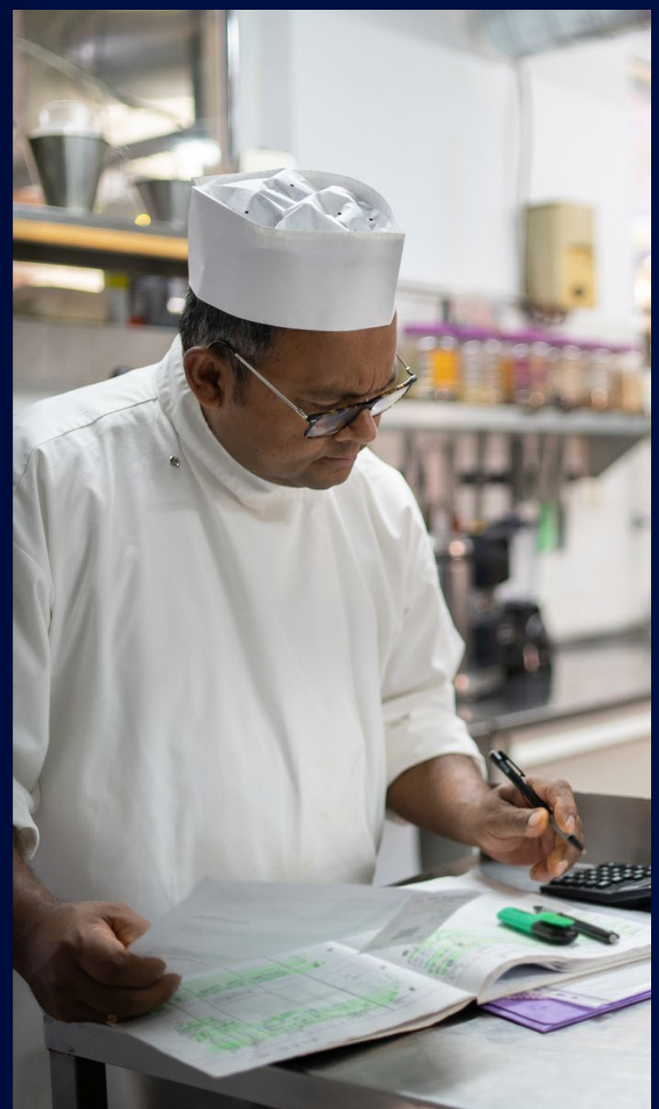


Fig. 7: How much of all food do chefs think will be made with new food products and ingredients in 2040?

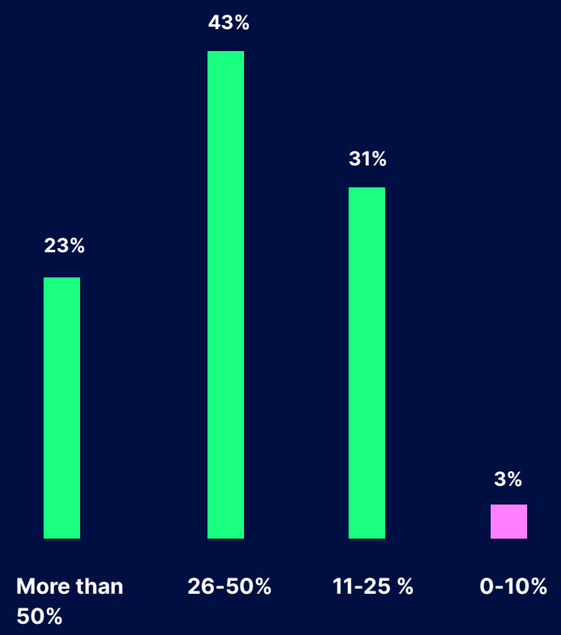
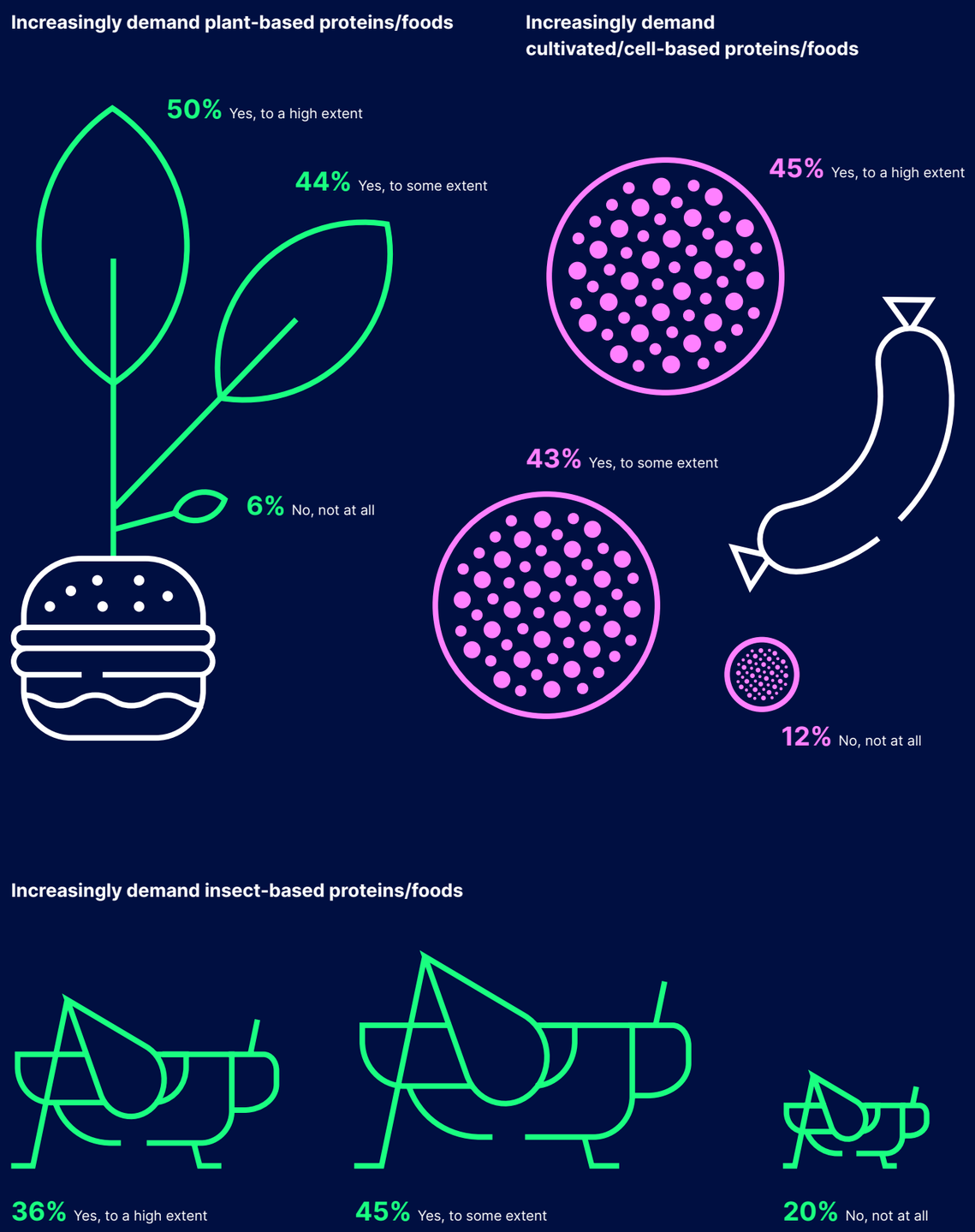


Fig. 8: Looking 10 years ahead, do chefs expect their guests to increasingly ask for alternatives to conventional food?

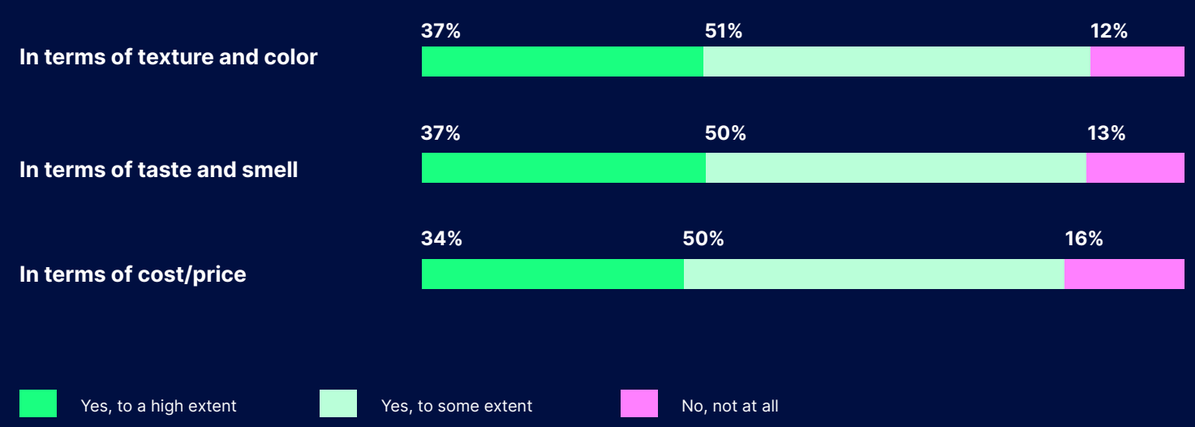


Wrapping up

Overall, the GEA Chef Survey makes clear that food professionals worldwide are largely open and positive with regard to alternative proteins. Some have their doubts, of course, but the survey data indicates that only about 10 percent of chefs can be classified as "skeptics." The remaining 90 percent is roughly evenly divided between what we might call "ambassadors" – who are clearly positive about the rise of alternative proteins, have already used new food, and are confident about its future potential – and "cautious adopters," who are generally positive but more reserved in terms of their use and outlook so far. Cautious adopters tend to feel that many of today's new food products have not yet achieved restaurant-level quality. This attitude is not surprising, especially since three-quarters of respondents work in higher-priced restaurants. This is also largely consistent with recent consumer survey results, which make clear that consumers in general – while largely open and positive about alternative proteins and their benefits – still want to see further improvements in quality. Indeed, the majority of chefs (70%) see improved quality as key to increasing the consumption of new food going forward.

But it is noteworthy nevertheless that roughly a third of chefs feel that today's alternative proteins have already achieved sufficient quality in taste, texture and price to replace conventionally produced foods to a large extent. This is a significant number – and a testament to the huge strides made in improving the quality of alternative proteins in the last several years alone. The overall level of interest among chefs in using alternative proteins reinforces a growing body of data that tells us the following: new food is not just a possibility, but the emerging new reality.

Fig. 9: Have new food options reached a quality level where they could replace conventionally produced food?



I believe there will be a further increase in the consumption of alternative foods as their taste and quality improve.

Chef, Germany

The ambassadors

The GEA Chef Survey on New Food revealed that chefs who have a personal eating preference – such as vegetarian, pescatarian or vegan – are considerably more knowledgeable and positive about alternative proteins. But other characteristics also correlated positively with greater interest, engagement and optimism with regard to new food. Chefs in Asia, for example, are generally more familiar with alternative proteins and optimistic about technological progress driving increased consumption. Accordingly, they feel more strongly that their restaurant guests will increasingly demand alternative proteins in the coming years. Female chefs consider themselves particularly knowledgeable about new food and feel more strongly than their male counterparts that new food is already approaching the same quality level as conventional food. In addition, younger chefs are more experienced with new food and feel more strongly that they themselves are driving the new food trend among restaurant goers.

Survey methodology

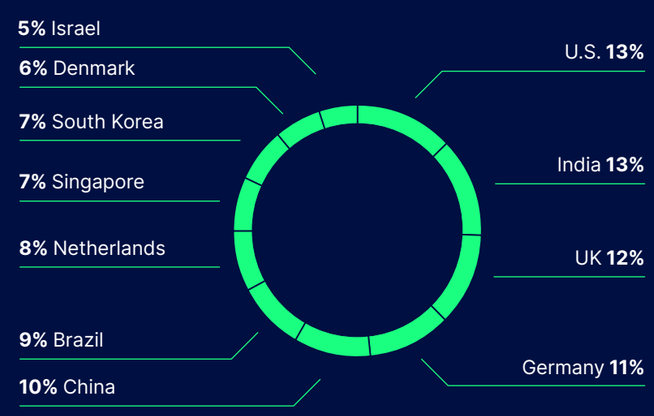
As one of the world's largest suppliers of systems and components to the food industry, GEA has an interest in knowing what chefs think about new foods and to what extent they are already preparing food based on meat and dairy alternatives. In 2022, GEA partnered with market research agency Lindberg International to conduct the GEA Chef Survey on New Food. The survey team developed the questionnaire based on four in-depth explorative telephone interviews with chefs in Denmark, Germany, Spain and the UK. After creating the survey and translating it into local languages, Lindberg International conducted 1,002 online interviews (in August 2022) with chefs in 11 different countries throughout the Americas (Brazil, U.S.), Europe and Middle East (Denmark, Germany, Israel, Netherlands, UK), and Asia (China, India, Singapore, South Korea). This global approach also helped identify some interesting geographical differences in chefs' attitudes towards new food.

Fully 60 percent of the chefs surveyed work in a restaurant in a metropolitan area or larger city. Three-quarters also indicated that their restaurant is more expensive than the average in their country. And they're busy! Almost all prepare food themselves, but the majority also perform other tasks such as planning the menu, ensuring the quality of service, purchasing supplies, and managing staff. More than half of the chefs avoid animal products in their diet to some extent. One-third are flexitarians who eat some meat, while 12 percent are vegetarian, 8 percent pescatarian, and 3 percent vegan. Sixty-nine percent of the chefs surveyed were male, 31 percent female; the average age was 35.

Cultured meat is the only thing that can really become a game changer. It's even better than normal meat.

Chef, Netherlands

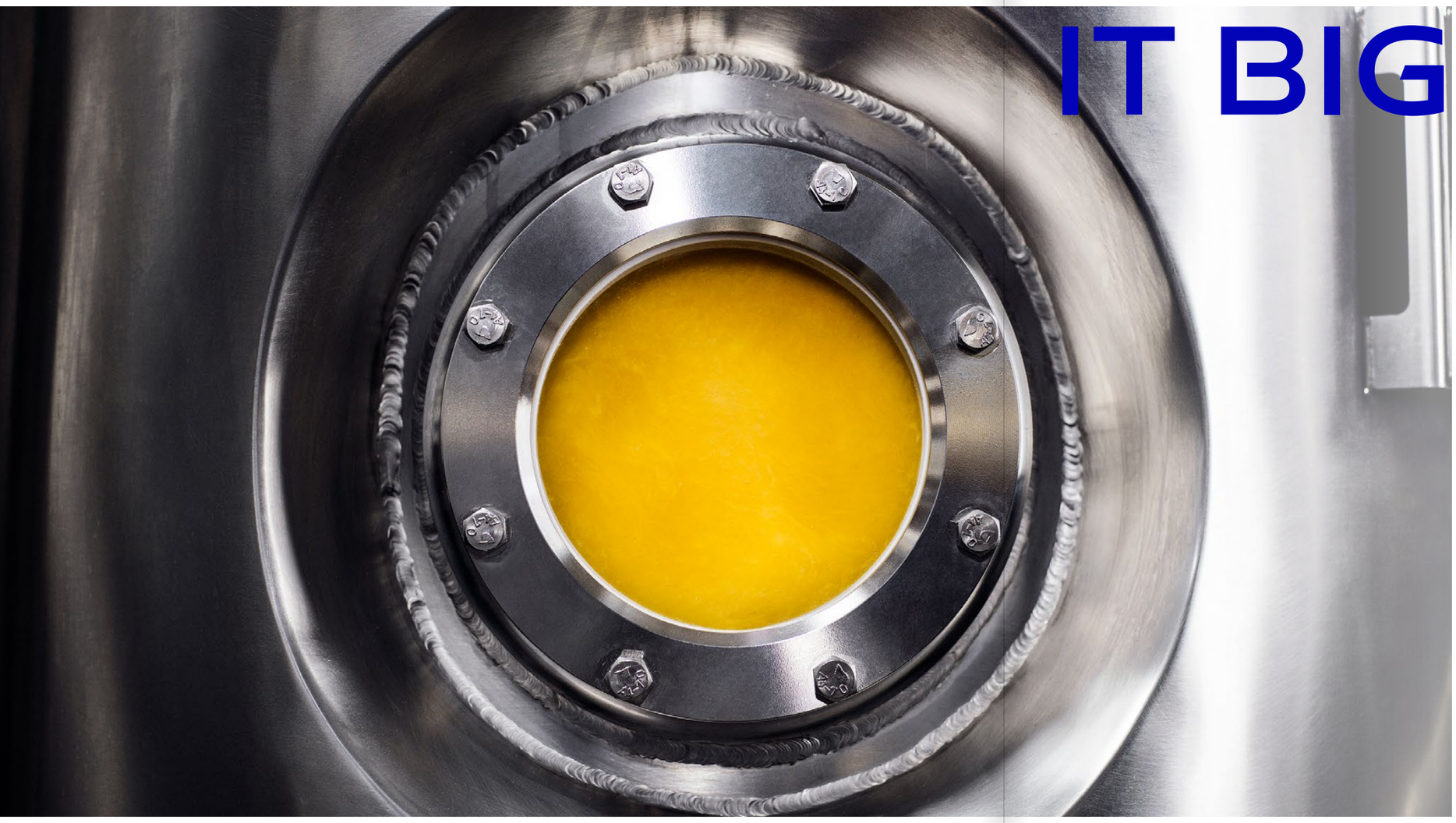
Country



Gender & Age

69% Male **31%** Female

MAKING IT BIG



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THE ROAD TO SCALABILITY

Enhancing the quality, quantity and impact of alternative proteins through technological innovation and efficient industrial processes

The alternative protein industry has made rapid progress in just the last several years. Plant-based burgers are increasingly indistinguishable from their ground meat counterparts, microorganisms are converting biomass into larger volumes of protein and other key ingredients, and cultivated meat has moved from the lab to pilot production facilities, attracting the interest of more and more researchers, companies and investors. Some of these novel proteins are further along in their development than others, but all have made significant breakthroughs. Technologies are proving viable and products marketable, largely because more and more consumers are demanding foods that are healthier for the planet and for themselves.

A 2022 global consumer survey conducted by Blue Horizon and Boston Consulting Group reveals that people are increasingly open to alternative proteins: 76 percent of survey respondents were aware of alternative proteins, 60 percent had experience with them and 55 percent had already consumed them. Significantly, the survey also found that consumers still want to see further progress in the taste, health and price of novel proteins. Despite the great strides made by leading companies such as Beyond Meat and Impossible Foods, these and other producers will continue to tinker with the mouthfeel, taste and nutritional profile of their products. And once they have achieved the desired parity with meat and other animal products, there will be little reason to stop there.

Technologies are proving viable and products marketable, largely because more and more consumers are demanding foods that are healthier for the planet and for themselves.

Fulfilling the alt protein promise

Indeed, the allure of alternative proteins is that once we have mastered the technology of meat alternatives – and successfully removed animals from the protein equation – there is no limit to the possibilities. Not only could they outperform conventional meat in terms of environmental impact and animal welfare, but they can also be continually optimized to create foods that are even healthier and more nutritious than the originals they set out to replicate. Across the alternative protein spectrum, the rapidly growing number of companies entering the space share a common vision: to be better than meat. And given the enormous demand for protein around the world, it's easy to understand why the flow of investor money is accelerating. In 2021, investment in cultivated meat companies was US$1.36 billion – more than double all previous investment.

But to realize their potential benefits to food security, climate, environment, human health and animal welfare, alternative proteins will have to be produced on a massive scale. A look at some of the primary levers for achieving scalability reveals that technological innovation and efficient industrial processes will be key to increasing both the quantity and quality of alternative proteins moving forward.

US$1.36 bn

was invested in cultivated meat companies in 2021 – more than double all previous investment.

Plant-based priorities

Plant-based proteins are the most advanced of today's alternative proteins in terms of scale, availability and uptake, but still cost roughly twice as much as conventional animal protein to produce. As it turns out, the primary levers for improving cost efficiency can also boost product quantity, quality and sustainability. This begins with optimizing plant-protein crops. Soybeans

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Across the alternative protein spectrum, the rapidly growing number of companies entering the space share a common vision: to be better than meat.

and yellow peas, for example, are two of today's main sources of plant-based protein, but both remain suboptimal for producing large quantities of tasty, nutritious human food. Soybeans, especially, are still used primarily for animal feed. Breeding these for better taste and higher protein content would boost both quality and scalability.

Another key to improving protein quality and yield is the right industrial processing technology. Each protein crop has its own unique composition and properties. Making sure the machines match the raw material can improve protein extraction (quantity) while reducing off-flavors (quality), reduce the need for chemical additives, and generally streamline capital intensive steps like separation and drying. Matching processing equipment to the given raw material also ensures effective capture and use of the respective byproducts such as starches and oils, which further reduces wastage and boosts profitability for producers.

Next steps for microorganisms

The alternative proteins used in new foods are produced mainly via biomass and precision fermentation of microorganisms. Metabolic efficiency plays a huge role in how effectively microorganisms convert feedstock into protein. This conversion is happening in bioreactors that stir and aerate the mixtures in a soup of carefully combined nutrients. Getting these conditions right allows producers to generate more protein from less input in less time – all of which advance the cause of scalability. Improving metabolic efficiency can also mean less build-up of off-flavors for improved quality and taste.

The right technological setup can help new food producers to improve processes and scale production.

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Many of the companies involved in the production of cultivated meat are just now transitioning from the lab to larger-scale pilot production.

Another key efficiency lever is optimized harvesting and purifying of precision fermentation proteins – a multi-step process to get from the suspension in which microorganisms are grown to the final protein extract. Centrifugation, filtering and drying are among the steps critical to efficient extraction; this is also where advances in industrial technology can decrease the cost of liquid-solid separation and have a major impact on product quality and scalability. On the upstream side, the efficiency and scalability of precision fermentation can be further improved by using low-cost feedstocks, such as byproducts from other industrial processes. This reduces production costs and boosts sustainability gains at the same time.

The keys to cultivated meat

Cultivated meat has made tremendous gains in cost efficiency since the famed US$325,000 in vitro burger made a splash in 2013 – but remains at least 10 times costlier to produce than conventional meat. Achieving scale and price parity with conventional meat will require a combination of innovation breakthroughs and cutting-edge manufacturing processes that will allow companies to grow cells more efficiently.

Efficient cell growth begins with the right cell lines. These are the breeder cells – the embryonic or adult stem cells taken from animals that give rise to different cell types. Every cell type has different growth potential and requirements, which means there is no single, standardized cell line identified for efficient production of cultivated beef, chicken, seafood, etc. Instead, a growing number of cultured meat companies are each conducting their own proprietary search for the perfect starting cells and exploring

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Whether producers harness microorganisms to make protein or cultivate animal cell lines for cultured meat, the bioreactors in which these processes take place play a critical role in scaling production.

ways to further enhance existing lines. Just as soy can be engineered for better taste and higher protein content, so can animal cells be developed to produce fewer unwanted byproducts, for example, for more efficient, larger-scale production of the desired tissue.

Cells grown outside an actual body still need to be fed, of course, and this is the job of the cell culture media – the mixture of nutrients and growth factors in which the cultivated cells bathe. As of today, the high cost of cell media is one of the greatest obstacles to achieving price parity with conventional meat, which is why the industry has taken steps to replace expensive ingredients, such as animal serum, with less costly animal-free ingredients. Matching cell media to specific cell types is another away to significantly boost cost efficiency and yield.

Getting bioreactors ready for upscaling

Whether producers harness microorganisms to make protein via precision fermentation or cultivate animal cell lines for cultured meat, the bioreactors in which these processes take place play a critical role in scaling production. By the end of 2021, there were 107 companies worldwide involved in the production of cultivated meat, and many of them are just now transitioning, or have only recently transitioned, from laboratory to larger-scale pilot production.

A key challenge these companies face is that cells don't necessarily behave the same in lab-scale bioreactors as they do in the industrial-scale bioreactors designed to generate hundreds of thousands of liters of product as cost-effectively as possible. Maintaining the delicate balance of pH, temperature, pressure, cell density and other factors requires machines and process lines fine-tuned to the needs of the given microorganism or cell culture. In the case of precision fermentation, a primary challenge is to remove the metabolic heat produced by the microorganisms. In the case of animal-cell cultivation, large volumes of media need to be rotated, stirred and aerated while minimizing shear stress, which can damage or kill the cells and ruin the entire crop. If the process is too slow, however, the yield might be too low. This would result in unnecessarily high energy costs or ineffective downstream processing – with negative effects on economic viability.

Overall plant efficiency

Efficient manufacturing processes have the power to contribute significantly to the overall economy and sustainability of alternative proteins. Among the many milestones achieved by the cultivated meat industry in 2021 was a government-industry cooperation on a life cycle assessment (LCA) involving Singapore's Agency for Science, Technology and Research and more than 15 companies along the cultivated meat supply chain. While the LCA confirmed the huge benefits of cultivated meat in terms of resource use, it also made clear that the climate benefits of alternative proteins will depend on the energy sources used in production. Leveraging renewable energy sources will be key, but industrial process design can have a major impact here as well. Designing process lines holistically – viewing production processes, heating and cooling as one symbiotic ecosystem – means food producers can lower energy usage and operating costs by as much as

30 percent and cut CO_2 and NOx emissions by up to 90 percent. These benchmarks have proven reliable in the context of many GEA food and beverage projects.

New food industry roadmap

Producing new food on an industrial scale presents major challenges, and much work remains before alternative proteins can make a dent in the US$1 trillion global meat market. But the industry is picking up speed and narrowing its focus on how best to achieve economies of scale. Across the alternative-protein spectrum, technological innovation and efficient industrial processes have been identified as the two main levers for boosting both the quality and quantity of desired end products.

Among the core innovation priorities are:

- Plant protein crops engineered for enhanced taste and protein content
- Microorganisms developed for high-efficiency conversion of feedstock into desired products
- Cell lines for cultivation that yield the best, most nutritious end product and in the greatest quantities, as well as inexpensive, non-animal cell culture media

Among the core industrial-process priorities are:

- Plant-based producers will need to match technologies to the given raw material to optimize protein extraction and effectively leverage byproducts.
- For fermentation and cultivated meat, efficient manufacturing will rely on smart bioreactors that cater to the needs of cell cultures or microorganisms and can monitor media, adjust it and reuse it by removing waste and adding nutrients.
- Holistic plant design to lower operating costs and significantly reduce greenhouse gas emissions during production.

As progress continues on these fronts, the new food industry will have to engage with consumers and other stakeholders to further familiarize them with alternative proteins and address any remaining concerns or questions regarding health-, nutrition- and safety-related aspects. At the same time, skilled and effective government regulation will be key to ensuring consistently high standards while promoting continued technological innovation and industry growth. If all these factors come together – innovation, manufacturing efficiency, consumer acceptance and government leadership – alternative proteins could truly transform mankind's impact on the planet.

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Efficient manufacturing processes have the power to contribute significantly to the overall economy and sustainability of alternative proteins.

"How will cultured meat and meat alternatives disrupt the agricultural and food industry?" A.T. Kearney, 2019

"Food for thought: The untapped climate opportunity in alternative proteins," Blue Horizon and Boston Consulting Group, July 2022

"Fermenters & Bioreactors for New Food," GEA.com

"Cell culture media and growth factor trends in the cultivated meat industry," The Good Food Institute, Sept. 2021

"State of the Industry Report: Cultivated meat and seafood," The Good Food Institute, 2022

"Cultivated meat: Out of the lab, into the frying pan," McKinsey & Company, June 16, 2021

"Is cellular agriculture the climate-friendly answer to growing food demands?" World Economic Forum, Nov. 4, 2021

"Sprungbrett in die industrielle Produktion," dei – Prozesstechnik für die Lebensmittelindustrie, Sept. 22, 2022

Sources

Cultivated meat on a roll

In 2021, cultivated meat achieved a number of milestones that attest to the momentum building behind even the most ambitious of alternative proteins:

US$100 m

The world's largest meat company announced a **US$100 million investment in cultivated meat**, with plans to market it by 2024

21

new companies, including the first companies in Mexico, Brazil and Africa, joined another 86 already involved in cultivated meat production

China included cultivated meat in its latest **five-year agricultural plan**

A **long list of strategic business partnerships** and industry organizations were formed to promote collaboration

Several **new, pilot-scale production** facilities were launched

Governments and industry cooperated on the **first life cycle assessment** of cultivated meat

THE TIP OF THE ICEBERG

In 2022 GEA established its New Food business unit, primarily dedicated to cell-based protein production. Leading the unit is **Heinz Juergen Kroner**, who spoke to us about GEA's position as a global supplier of process technology, and how GEA plays a key role in supporting this burgeoning industry.

Heinz Juergen Kroner, GEA

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Our aim is to support projects that we have evaluated thoroughly, from a business as well as a scientific perspective. Deep collaboration is required to succeed.

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GEA's center of competence for bioreactors provides customers a place to test processes and ingredients, as well as develop solutions that contribute to higher bioreactor capacity and performance.

Why did GEA decide to engage in the new food business?
Because we have the know-how to make a difference. Due to our longstanding experience as a supplier for the food industry, we are well-prepared to serve the market around alternative proteins, especially those from plant-, cell- and microorganism-based sources. Many of these new foods require liquid processing, which is a field we know very well at GEA. We've been innovating in this area for decades, for example with our centrifuges, homogenizers or valves and pumps. In fact, many technologies needed to create alternative proteins are quite similar to those we use when producing traditional foods or even pharmaceuticals.

With our core competencies we believe we can support many companies at the forefront of plant-based and cell-based food development. Our engineers, processes and machines can meet nearly any of their requirements.

What did you learn when entering the new food market?
The basic technologies used to produce alternative proteins are very much at the core of GEA's business, but the configuration – the exact combination of machines and processes – differs. Adapting our machines to specific customer needs in this market requires diving deep, constantly adjusting the technology and patiently building up unique know-how. So it's really important for us to have a dedicated New Food team working on this.

How else does the new food market differ from GEA's traditional business?
It is structured quite differently, both in terms of customer perspective and expectations. Our traditional customers in the brewery or dairy business, for example, usually come to us with a very clear and robust idea of what they want to build. They already know their processes; they know their pre-products and end products, and how to handle them most efficiently. So, we usually build according to very clear specifications.

In this new field, which is very startup-dominated, we often deal with customers who have a great idea on lab scale. They turn to us to help them bring their laboratory ideas or pilot trials to an industrial level. We work closely with them to find out if this is possible.

For startups, "failing quickly" is critical, because they have more financial exposure. GEA recently introduced a Mobile Test Center, which allows companies to generate a true proof-of-concept for their processes. This helps a business scale-up to commercial production of cell-based food products and nutritional components, without having to invest in a full pilot plant. We already see strong demand for this solution.

Are you focused on working exclusively with startups?
Not at all. While there are indeed many start-ups, we also work with some very big players in the food industry. They have a strategic interest in entering this new field to protect their business going forward. These include some big household names in the food segment, as well as large food ingredients producers, such as our customer Novozymes.

Are there expectations that both startups and big players have in common?
Most customers don't like too many interfaces. They prefer a one-stop shop, since integrating multiple suppliers and different technologies increases complexity and risk. Getting to market quickly is also a priority, so they value excellent and reliable project management. A track record of delivering on time, on spec and on budget is universally appreciated. Naturally, this is an opportunity for an organization like ours.

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Our Mobile Test Center can help a business scale-up to commercial production of cell-based food products without having to invest in a full pilot plant.

In your view, what is the most important ingredient for successful collaboration?
I think trust and humility are required in this fast-moving sector. On the one hand, you have some very new, smart ideas which customers are keen to protect. They need to be able to rely on their partners. On the other hand, it's clear that both parties cannot know everything, given how quickly technology and the market are changing. This is where ongoing dialogue and mutual openness helps. When considering proposals, we make sure to ask any unanswered questions. We also spend time looking at their business plans and objectives. Our aim is to support projects that we have evaluated thoroughly, from a business as well as a scientific perspective. Deep collaboration is required to succeed.

What are the next frontiers for the industry?
Scaling of course remains a challenge. Most lab-scale trials run at the pharmaceutical level. This means that hygienic, aseptic and processing requirements are so sensitive that scaling up to industrial production is really difficult – not just technologically, but also in terms of costs. The key is to maintain the high quality yet scale to the level required for industrial food production.

This also requires more – and in many cases larger – bioreactors. Particularly cell-based foods such as cultured meat will need a lot more bioreactor capacity to really take off. As a result, we can expect many plants to be built in the next decades. To help meet this demand, GEA established a center of competence for bioreactors in Denmark in 2022. Our goal is two-fold: first, to provide customers a place to test processes and ingredients; and second, to develop solutions that contribute to higher bioreactor capacity and performance.

Another related topic is the cost of materials, particularly growth media for producing cultivated meat. These are difficult to produce and quite fragile. GEA actively looks for ways to help here as well. For example, we will continue to optimize our centrifuges and homogenizers to maximize yield as well as look for ways to reuse cell growth media.

And while upstream processes are vital, it is not enough to simply produce a lot of cells. What ultimately counts is creating an end product that consumers will buy, time and again. At GEA, we go to great lengths to help customers test and tweak food concepts that consumers will enjoy eating. Mouthfeel, bite and sensory engagement, for example, ensure food provides the experience consumers expect and are key to increased uptake. These are the very things we help customers with at our dedicated Food Solutions Technology Centers in the Netherlands and the U.S.

What needs to happen to encourage more people to integrate alternative proteins into their diet?
We already see fast-growing demand for these proteins, especially in regions like Europe and North America. Just look at the growing shelf space in supermarkets. This is driven by the popularity of vegetarian and vegan diets, and by more people adopting a flexitarian lifestyle. Of course, plant-based proteins are largely responsible for this growth so far.

The production of cultured meat and other cell-based foods is still in its infancy. Here, things like taste, mouthfeel – and of course price – will be key to consumer uptake. Producers, regulators and scientists also have a lot of work to do when it comes to explaining such products and the technologies behind them. Acceptance and transparency are key. People need to understand that cell-based foods are scientifically sound and perfectly safe. Cultured meat is real meat; it is simply grown differently. In addition, it will be key to inform people about the potential health benefits as well as the great environmental and ethical opportunities.

What gets you most excited about the new food industry?
In my view, it is just amazing to see what we can do with the help of science – to develop completely new food products, or create traditional products in an entirely new way. And there are still so many hidden opportunities we can tap into. This is just the tip of the iceberg in terms of what will become possible in the future. What makes me particularly proud is that GEA plays such a crucial role as an enabler. We are really helping this new field to grow faster and to bring new ideas to reality.

Will alternative proteins save the world?
At the end of the day, it's clear that we must take pressure off the environment and reverse the trajectory of global warming. At present, food production accounts for about one-third of total global greenhouse gas emissions. So it's vital that we increase the efficiency of food production, particularly when it comes to protein-rich foods, like meat and dairy products.

Going forward, I believe that plant- and cell-based foods have a major role to play in achieving that objective. And I am quite sure that these foods will succeed in meeting the high expectations placed on them. We are already seeing rapid improvements along all key dimensions – price, quality, taste and availability.

And while I am very optimistic about the potential of new food to sustainably feed the world, I also believe conventional food will continue to co-exist with new food. I have a lot of respect for our farmers and food producers, and I hope that we all gain a greater appreciation for the quality and true value of traditional foods – and for the privilege of having it available.

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At our dedicated Food Solutions Technology Centers in the Netherlands and the U.S., we help customers test and tweak food concepts that consumers will enjoy eating.

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Transparency is key. People need to understand that cell-based foods are scientifically sound and perfectly safe.

Heinz Juergen Kroner

Senior Vice President, Liquid Technologies and New Food business units, GEA

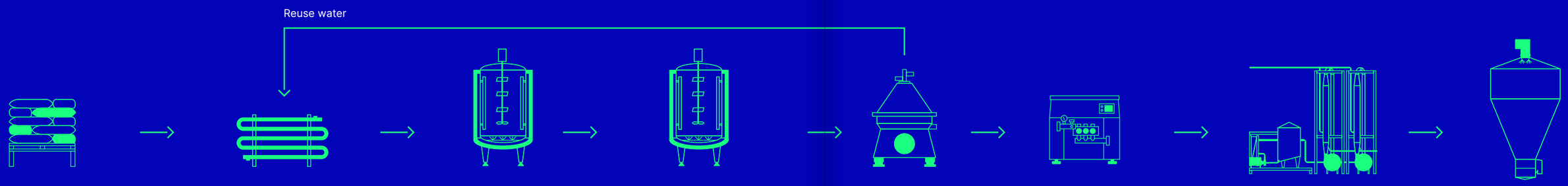
Heinz Juergen Kroner has led GEA's Liquid Technologies business unit since 2018 and its newly established New Food unit since 2022. He previously held management positions in various companies producing process technology for the food and beverage industry, with expertise in strategic corporate development and new business.

FROM PROCESS TO PLATE

A 3D-printed steak made from cultured or precision-fermented meat, a plant-based burger with the real meat umami: Behind the familiar look and feel of today's new foods are sophisticated technologies and processes designed to mimic the miracle of biology.

Microorganism-based precision fermentation

Microbes act as mini factories to produce functional ingredients like rennet for cheese, as well as vitamins, flavors, proteins, pigments and fats.



Raw materials
Typically sugar and ammonia water

Mixing and sterilization
To remove unwanted organisms

Cultivation
To grow organisms

Fermentation
Stress the cells to make them produce the desired product

Harvest
Separate cells from media

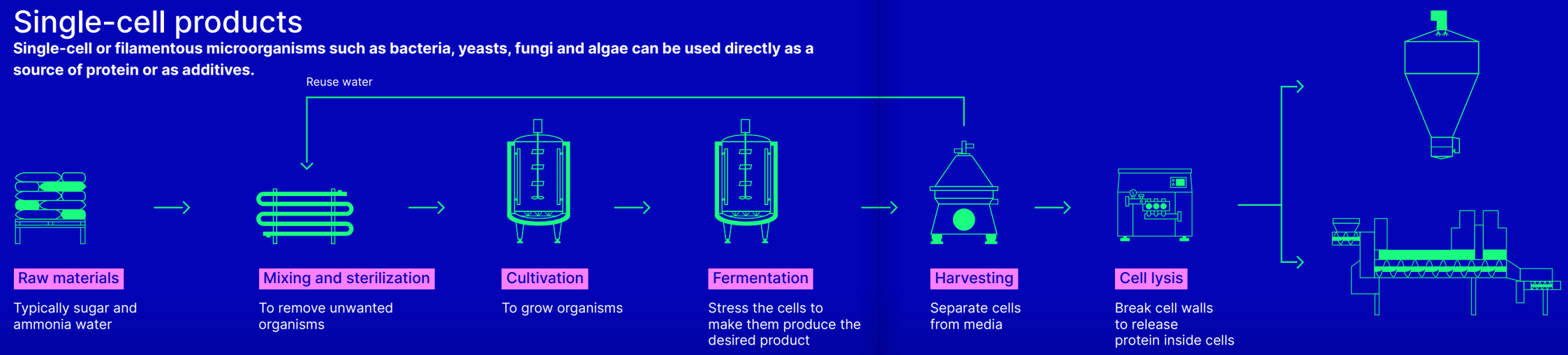
Cell lysis
Break cell walls to release protein inside cells

Purification
Separate out desired protein

Drying
Protein is dried into powder that can be used as an ingredient in plant-based meat alternatives to improve taste

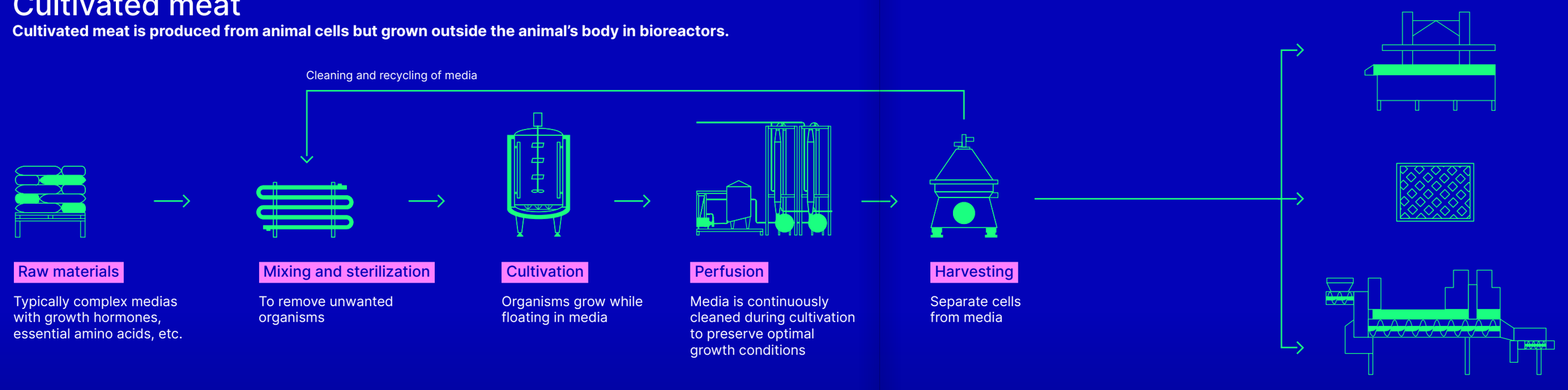
Single-cell products

Single-cell or filamentous microorganisms such as bacteria, yeasts, fungi and algae can be used directly as a source of protein or as additives.



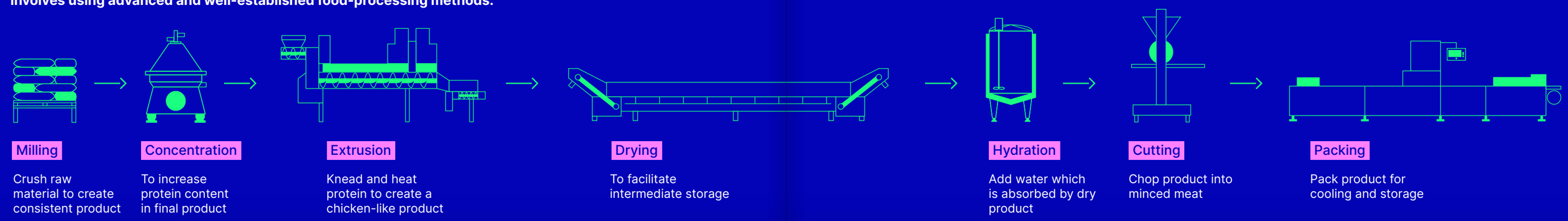
Cultivated meat

Cultivated meat is produced from animal cells but grown outside the animal's body in bioreactors.



Plant-based meat alternatives

Producing plant-based alternatives for burgers and other meat-analogue products often involves using advanced and well-established food-processing methods.



TRANSFORMING FOOD TECH

The Kitchen FoodTech Hub is a government-backed Israeli food-tech incubator helping young companies commercialize their innovative technologies and accelerate progress towards more sustainable food systems.

Technology expert **Dr. Dorit Rozner** talks about how The Kitchen promotes entrepreneurship in Israel's flourishing field of new food.

Dr. Dorit Rozner, The Kitchen FoodTech Hub

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We are leveraging synthetic biology, AI and bioinformatics to help companies scale up and reduce the cost of producing their groundbreaking foods.

What is driving the food tech transformation?
We know today that food systems are responsible for nearly one-third of the world's greenhouse gas admissions and – critically – that these emissions continue to rise due to land-use change, waste management, animal husbandry, production and packaging. So we have many of today's best minds tackling this challenge with a sense of urgency, developing new and innovative technologies to produce more sustainable food.

What kinds of companies does The Kitchen include in its portfolio?
We're seeing a broad wave of innovation in food tech around the world – and that is reflected in the wide range of companies in our portfolio. We have companies taking plant-based foods to the next level by reducing the number of ingredients and additives in plant-based meat alternatives, such as Zero Egg. Yeap extracts a sustainable and inexpensive functional protein for food applications from downstream yeast. Others, like Imagindairy, are developing cutting-edge fermentation-based proteins for animal-free dairy products. We have companies creating functional ingredients to improve the taste and texture of plant-based products, cultivating meat, which eliminates the need to raise farm animals, or advancing solutions in food safety. Prevera, for example, develops antimicrobial proteins for use as preservatives by the food industry. Another interesting example is Bio-Fence, which has created an innovative technology that stabilizes disinfectants on surfaces. All of these companies share a desire to disrupt the food industry with innovative technologies that address urgent needs.

How does The Kitchen support these companies?
We're in the business of building companies – or more specifically: commercializing food technology startups. So, for the companies producing food via precision fermentation or cell cultivation, for example, we are focused mainly on helping them take that step from the lab to more commercial-scale production. Aleph Farms was our first cultivated meat company, and we recently added two companies cultivating fish and seafood: Wanda Fish and Forsea – all good examples of where we're leveraging synthetic biology, AI and bioinformatics to help companies scale up and reduce the cost of producing their groundbreaking foods.

What can other countries learn from Israel's approach to food technology and innovation?
The short answer is that Israel has prioritized investment in food technology. And that includes robust government funding. The Kitchen Hub, for example, recently won a new tender from the Israel Innovation Authority (IIA) which provides another five years of financial support for our biotech/food tech activities. According to The Good Food Institute, Israeli startups raised just over 1 billion shekels (US$320 million) during the first half of 2022; that is a 160 percent increase over last year, and second only to the U.S. in fundraising in this field. In general, we have a strong entrepreneurial culture in Israel. Food tech is also extremely attractive to innovators because it can make such a positive impact on the environment and human health.

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Israel has prioritized investment in food technology. And that includes robust government funding.

Dr. Dorit Rozner

Chief Technology Officer
The Kitchen FoodTech Hub, Israel

As head of The Kitchen's Technology division, Dorit supports innovative alternative protein companies in bringing their ideas from concept to finished products. She earned a PhD in organic chemistry from the Weizmann Institute of Science in Rehovot/Tel Aviv, and has more than 15 years of experience managing global R&D in functional food, dietary supplement and pharmaceutical companies.

THE WAY FORWARD

Protein evolution 62

The next chapter in agriculture 68

Today, alternative proteins are no longer about serving a niche market; they're about fundamentally transforming the way human beings eat and impact the planet.

PROTEIN EVOLUTION

As the alternative protein industry matures, it will rely on support from an increasingly wide range of stakeholders.

58%

was the increase in global meat consumption between 1998 and 2018 – just two decades.

Over the last several decades, consumption of alternative proteins in the West was largely limited to a small percentage of consumers looking to avoid lactose or animal protein for health and/or ethical reasons. For the overwhelming majority of consumers on the planet, the goal has been more meat, not less.

In the two decades between 1998 and 2018, global meat consumption increased by 58 percent – a trend largely driven by population growth and the burgeoning middle class in countries like China and India. Between 2010 and 2019, average global per capita consumption of meat also increased by roughly 4 percent. But growing concern for the fate of our planet has turned attention to conventional meat's environmental impact and triggered an explosion of interest in more sustainable alternatives foods.

In just the last few years alone, hundreds of companies across the alternative protein spectrum – from plant-based, to cell-based to insect-based – have thrown their hats into the ring. Nearly all of them share the same "big idea": to remove animals, or at least animal rearing, from the protein equation. It's an idea with increasingly widespread appeal. More and more stakeholders – from consumers, to investors, food companies, equipment manufacturers and policymakers – believe that alternative proteins, if produced and consumed on a large enough scale, could accelerate progress towards multiple climate, environmental and food security goals.

Today, alternative proteins are no longer about serving a niche market; they're about fundamentally transforming the way human beings eat and impact the planet.

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It is no longer a question of whether cultured meat technology is feasible, but how fast it can produce quantities enough to be commercially viable.

A young industry matures

With a growing sense of urgency – and opportunity – driving progress in alternative proteins, the industry has entered a new phase in its development; it is maturing. Impressive advances in the taste and texture of plant-based proteins have taken these once-marginalized meatless products mainstream. Now, increasingly savvy and health-conscious consumers are pushing producers to take the next steps – to minimize processing, for example, or find more natural alternatives to man-made additives.

Fermentation technologies have proven their ability to produce large volumes of alternative proteins and thousands of other useful compounds. Now companies are exploring new strains of microorganisms with greater metabolic efficiency for improved quality and quantity. Meanwhile, gas fermentation offers a way to remove agricultural products, such as sugar, from the fermentation equation entirely. The Finnish company Solar Foods, for example, has harnessed a microorganism that requires only carbon dioxide, hydrogen gas, oxygen and ammonium to generate the carbon compounds (amino acids, carbohydrates and fatty acids) necessary to nourish us. Their product – a nutrient-rich powder containing 67 percent protein – is turning science fiction into reality.

Cultured meat has also taken the next step in its evolution. It is no longer a question of whether this technology is feasible, but how fast it can produce quantities enough to be commercially viable. The leading companies have moved on to establishing large scale production facilities with next-generation bioreactors, some of which are tailored to specific cell cultures and able to reuse expensive growth factors and cell culture media. And efforts are already underway to enhance the nutritional profiles of cultured meats (e.g., with vitamin B12 or omega-3 fatty acids).

In another sign of a maturing industry, hybrid solutions are combining the strengths of different alternative protein types to create more advanced end products. Precision fermentation products such as heme, casein or vitamins, for example, are greatly enhancing the quality of plant-based protein. At the same time, plant-based proteins are being added to cultivated meat products as a quick way to lower their price point.

~75%

of consumers internationally are already aware of alternative proteins. More than half have already consumed them.

Stakeholders step up

Today's alternative protein industry is rightly focused on innovation and efficient industrial processes as the key to achieving scalability. For the industry itself, this is the next major maturity test and likely the single biggest factor in realizing the full potential of alternative proteins. But progress is needed in other areas as well. Consumer acceptance and regulatory support are two critical areas that will have to keep pace with technological progress.

Recent surveys point to a growing openness among consumers to alternative proteins. Roughly three-quarters of consumers internationally are already aware of alternative proteins, for example, and more than half have already consumed them in one form or another. Nearly 40 percent of chefs surveyed by GEA in 2022 already use meat alternatives to a high extent in their restaurants, and over 40 percent of chefs report a high degree of increased demand for meat alternatives among their customers.

As consumers become increasingly aware of food as a factor in health of the planet, they are also increasingly aware of food as a factor in their own health. Surveys indicate that consumers want to see continued progress in the taste, texture and price of alternative proteins, but they also want assurances when it comes to health and safety. In the case of plant-based proteins, producers are already taking steps to address this issue by minimizing processing and exploring more natural alternatives to common additives.

In the case of cell-based proteins, the challenge runs deeper. While plant-based (and insect-based) proteins are relatively easy to understand, it is much less obvious to consumers how cultivated meat or fermentation-based proteins are made. Here, it is important to make consumers aware of the health and environmental benefits, as well as the supply chains, technologies and production processes behind alternative proteins. Transparency will be key to making consumers feel comfortable with these new foods and building trust. Some cultivated meat companies are already prioritizing this aspect, engaging consumers with product testing and exploring ways to locate production facilities closer to the consumer. A leading (and literal) example of transparency comes from Upside Foods in Berkeley, California, whose new East Bay facility allows the public to peer through massive windows onto its production floor.

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With producers focused primarily on innovating and scaling up production, it is critical that governments keep pace by establishing deep expertise in the field and maintaining open lines of communication with all stakeholders.

"Food for thought: The untapped climate opportunity in alternative proteins," Blue Horizon and Boston Consulting Group, July 2022

"Global animal farming, meat production and meat consumption," Destatis Statistisches Bundesamt, 2022 edition, Aug. 2022

"Meat no longer requires animal slaughter," The Economist, Technology Quarterly, Sept. 28, 2021

J.P. Pitkänen, "An elemental perspective to food production: Solar Foods produces a novel ingredient out of electricity and air," Solarfoods.com, Aug. 17, 2022

T. Whitnall, N. Pitts, "Meat consumption: Analysis of global meat consumption trends," Dept. of Agriculture, Fisheries and Forestry, Australian Government, 2019

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Regulation that promotes and protects

Regulation, of course, has a major role to play when it comes to building trust. With producers focused primarily on innovating and scaling up production, it is critical that governments keep pace by establishing deep expertise in the field and maintaining open lines of communication with all stakeholders. This will help regulators refrain from unnecessary bureaucracy while keeping quality and safety standards high.

At the time of writing, the commercial sale of cultivated meat has received regulatory approval in only one country (Singapore) thus far. Nevertheless, considerable progress has been made on this front over the last several years. After Israel got the ball rolling in 2015 with a regulatory framework for "novel food," government attention to alternative proteins has accelerated. As of 2022, 13 major countries in Asia, Oceania, Europe and the Americas have taken action to formalize and support the plant-based, fermentation-based and/or animal-cell-based industries. In 2020, the Netherlands announced its National Protein Strategy; in 2022, China included support for plant-based proteins and those produced by microorganisms in its latest five-year plan. The United Nations plans to develop recommendations in 2023. Additionally, the U.S. Food and Drug Administration (FDA) rated cell-grown chicken from manufacturer UPSIDE Foods as safe in November 2022 – a big push in terms of marketability of new foods.

The bigger push towards resilience and sustainability

New food visionaries have been talking about the wide-ranging benefits of alternative proteins for many years. Now the secret is out – and it's becoming ever clearer to the full range of stakeholders that reducing our dependency on traditional animal agriculture could have a major positive impact not only on global warming, but other critical issues such as resource scarcity, environmental degradation and food security. On the latter issue, governments from the Netherlands to China have taken note: alternative proteins represent a reliable – and eventually affordable – source of protein with more resilient supply chains. Not only can they reduce a country's dependence on imports, but also make food production less dependent on weather conditions or political winds.

The processes being harnessed to produce alternative proteins are, in fact, powering innovation across multiple industries. Fermentation is already used to make insulin and non-toxic pesticides, for example. Filamentous fungi can form meat-like proteins, but also biodegradable packaging. And cell cultivation is already being used for advanced cell therapies in medicine. The fact that new food technology – such as fermenters or bioreactors – has multiple game-changing applications is likely to further embed these technologies in our supply chains and further expedite their efficiency and economy. Alternative proteins are just one part of a larger biotech revolution and shift towards producing everyday products in vastly more sustainable ways. As futuristic as some of today's new food breakthroughs might seem, they are indeed just the tip of the iceberg.

THE NEXT CHAPTER IN AGRICULTURE

Bruce Friedrich, The Good Food Institute

Carlotte Lucas, The Good Food Institute Europe

The Good Food Institute (GFI), a nonprofit think tank and international network of organizations, sees alternative proteins as an essential solution to meet the world's climate, global health, food security and biodiversity goals.

We spoke with **Bruce Friedrich**, President and Founder, and **Carlotte Lucas**, Corporate Engagement Manager, about how GFI is advancing alternative proteins, how new players are making an impact and what needs to happen for alternative proteins to fulfill their potential.

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We're seeing increased acknowledgement of alternative proteins as a climate and food security solution, with governments around the world taking note and beginning to act.

Bruce Friedrich

What are the most promising developments in the alternative protein sector?

Bruce Friedrich: A few come to mind. We're seeing significant developments and momentum in the areas of science, innovation, talent and public and private sector support. We're also seeing increased acknowledgement of alternative proteins as a climate and food security solution, with governments around the world taking note and beginning to act.

On the science and innovation front, advances in alt protein crop development, precision fermentation and cultivated meat technologies, to name a few, are happening fast, as more researchers and funding flow into the field. It's especially exciting to see new scientists from a diversity of disciplines, and at different points in their careers, jumping into alt protein research. At universities worldwide, new courses and even dedicated degree programs are being launched. Just this year, GFI's Alt Protein Project – a student-driven program aimed at turning universities into engines of alternative protein progress and innovation – is set to double to 32 universities across six continents.

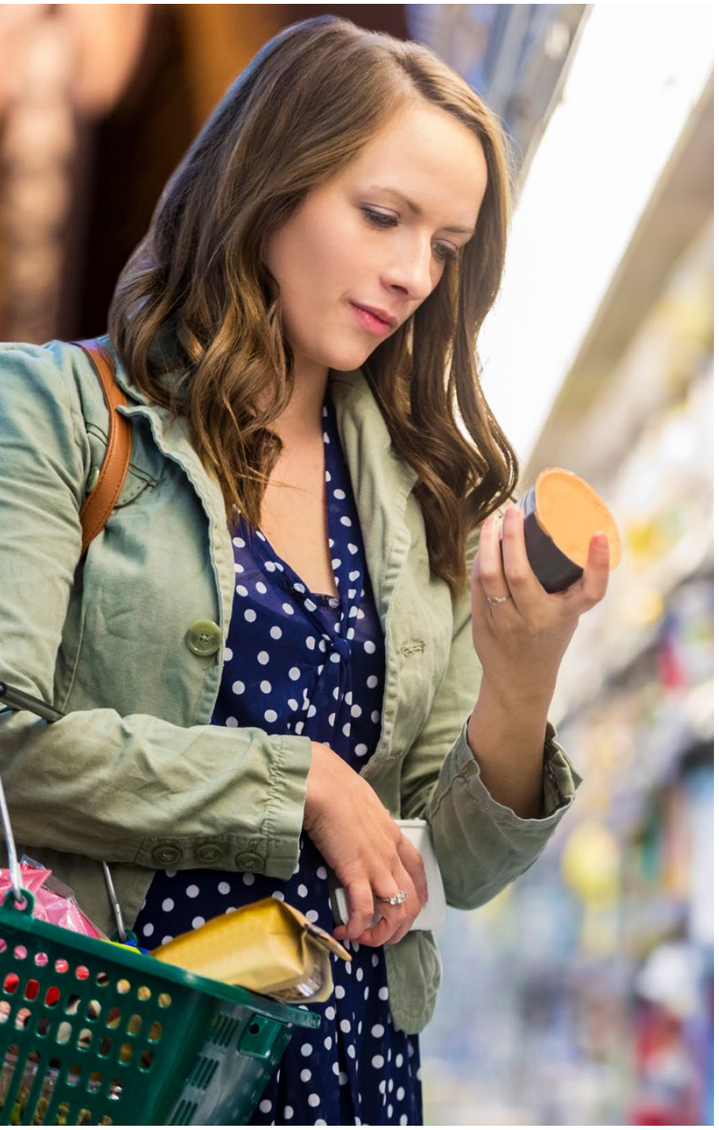
In terms of public sector, we're seeing governments around the world recognizing the advantages of alternative proteins and investing in them to meet national policy goals and create good-paying, sustainable jobs. Only five years ago, public funding for alternative protein R&D was close to zero. Today, the total exceeds US$300 million from more than a dozen countries, plus additional hundreds of millions of dollars in government investments in and incentives for alternative protein companies.

As more talent and significantly more funding flow into alternative proteins, the entire sector will pick up steam, offering the world a fundamentally different and far more sustainable food future.

Where do you see the key challenges moving forward?

Carlotte Lucas: Ultimately, if alternative proteins are to fulfill their potential of reducing emissions and contributing to a more sustainable food system, they need to become as tasty, affordable and accessible as conventional meat.

For plant-based meat, one of the key challenges is to develop "whole cut" products that deliver the taste and texture of steak, chicken breast, and fish filets, as opposed to the burgers, sausages and minced products that have dominated the market so far. And developing animal-free fat alternatives will be crucial to delivering the flavor and mouthfeel of conventionally produced meat.



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People want sustainable options – but they don't want to compromise on taste, price or convenience.

Carlotte Lucas

GFI's own research has shown that, if plant-based meat is to make up 6 percent of the global meat market by 2030, governments and the food industry must make significant investments along the entire supply chain. Research to develop protein-rich crop varieties, the construction of 800 or more large-scale production facilities, and greater ingredient processing capacity will all be essential to meet demand.

As far as cultivated meat is concerned, we've already seen some encouraging signs of interest from large companies in this space. But to scale up the production of cultivated meat and bring down prices, we need to see governments and companies invest far more in open-access research and infrastructure. This will be essential in every step of the process – from improving the scaffolding used to create the complex fibrous texture similar to that of conventional meat, to building larger fermenters in which the cells can grow.

How can the Good Food Institute help overcome these challenges?
BF: As a nonprofit, GFI can accelerate alternative protein market growth in ways that support and catalyze the entire field. While many innovators seek proprietary solutions to the same set of problems, our research, data and insights are open-access and support the advancement of the entire alternative protein space – around the world, across supply chains and across public and private sectors.

GFI channels funding toward the highest-impact research projects that address key knowledge gaps and technical challenges. We also publish tools, databases, reports and analyses that serve as the research foundation for the field. We bring together scientists to forge partnerships, develop and grow a thriving research community and cultivate new talent. Our alt protein webinars and workshops help both scientists and entrepreneurs across the field connect with each other, inspire each other and collaborate on solutions that would be impossible to tackle alone.

We offer expertise and resources to governments around the world working to achieve climate, food security, biodiversity and global health goals. Our focus here is on regional approaches to policy-shaping that are grounded in regional assets and strengths (e.g., indigenous crops) as well as economic development and equitable job creation. We also share data and insights on how different countries are navigating and developing regulatory frameworks, and publish global and regional state-of-the-industry reports that highlight replicable successes.

Are consumers around the world ready for plant-based meat and particularly for cultivated meat?
CL: They are certainly ready for plant-based meat. We know from our latest state-of-the-industry report that global sales were up 17 percent (to US$5.6 billion) in 2021 – a huge increase over the previous year.

Our recent Good Food Institute Europe survey found that half of Spaniards and Italians already eat plant-based meat on a monthly basis, and that one in four Germans plan to increase their plant-based meat consumption. The survey also revealed a growing awareness of cultivated meat. Fully 65 percent of Spaniards, 55 percent of Italians, 57 percent of Germans and a third of French consumers said they'd be willing to buy it when it comes on the market. Many also believe that governments should support this new way of making meat. This attitude reflected another recent study showing that 80 percent of UK and U.S. consumers were open to eating cultivated meat.

Ultimately, people want sustainable options – but they don't want to compromise on taste, price or convenience. Government support for R&D and infrastructure will allow these more sustainable foods to compete with conventional meat on those measures, and eventually become the default choice.

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While many innovators seek proprietary solutions to the same set of problems, our research, data and insights are open-access and support the advancement of the entire alternative protein space.

Bruce Friedrich

Are there any significant differences in attitudes and opinion across regions?
CL: We actually see a fair amount of consistency across regions. Our consumer survey for Europe revealed broad willingness to buy cultivated meat across the region and this is echoed by several recent academic studies. There has been similarly broad support for another important sustainable protein technology – precision fermentation – which uses organisms such as yeast to produce genuine egg or dairy proteins, along with other ingredients that deliver the familiar flavors and textures of foods like cheese and milk, without using animals.

One study found very high levels of acceptance, with 78 percent of consumers from a wide range of countries – Brazil, Germany, India, the UK and the U.S. – willing to try animal-free dairy cheese, and 70 percent willing to buy it.

We also see that consumers in other parts of the world consistently identify taste and texture as key drivers of acceptance moving forward. A 2021 study commissioned by the Good Food Institute Asia Pacific looked at the attitudes of consumers in Japan, Singapore, South Korea and Thailand. Taste was either extremely or somewhat important for 79 percent of consumers, while texture was either extremely or somewhat important for 72 percent across all four countries when it came to determining whether they would buy alternative seafood.

Across the world, there is a growing understanding of the importance of finding alternatives to animal agriculture, and huge opportunities for companies who get involved in this space.

Looking ahead, how can key stakeholder groups contribute most effectively to help alternative proteins realize their potential?
BF: I really appreciate this question. Success requires an all-hands-on-deck approach, and with every year between now and 2030, the stakes get higher. With demand for meat projected to double by 2050, we need less resource-intensive methods of protein production that are resilient enough to withstand the increasing pressures of supply chain disruption, global conflict and climate change.

Alternative proteins can satisfy growing demand, reduce pressure on the planet and enable sustainable agriculture. Alongside other advances and innovations in food and farming policies and practices, alternative proteins – specifically plant-based and cultivated meat – can help write the next chapter for agriculture in the U.S. and around the world. Everyone has a role to play.

The world's governments can lead by funding critical R&D to advance the science and scaling of alternative proteins, and by leveling the playing field to allow alternatives to compete on taste, price and convenience. Unlocking public funding and pursuing multilateral research and development partnerships can address the industry's biggest technical challenges, create new opportunities for growth and ensure these sustainable foods can benefit everyone. Governments can also embed alternative proteins in national climate change plans and national economic development plans. Investment tax credits, loan guarantees, demonstration projects and other forms of financial support from governments have catalyzed explosive growth in the renewable energy and electric vehicle sectors and can stimulate similar progress for sustainable protein infrastructure.

Companies can play a leading role by delivering tasty, affordable alternative protein products to mainstream consumers. This represents a significant market opportunity given the growing demand among consumers, who are increasingly concerned about the global impacts of conventional meat. Leaning into alternative proteins also enables companies to meet their environmental, social and corporate governance goals.

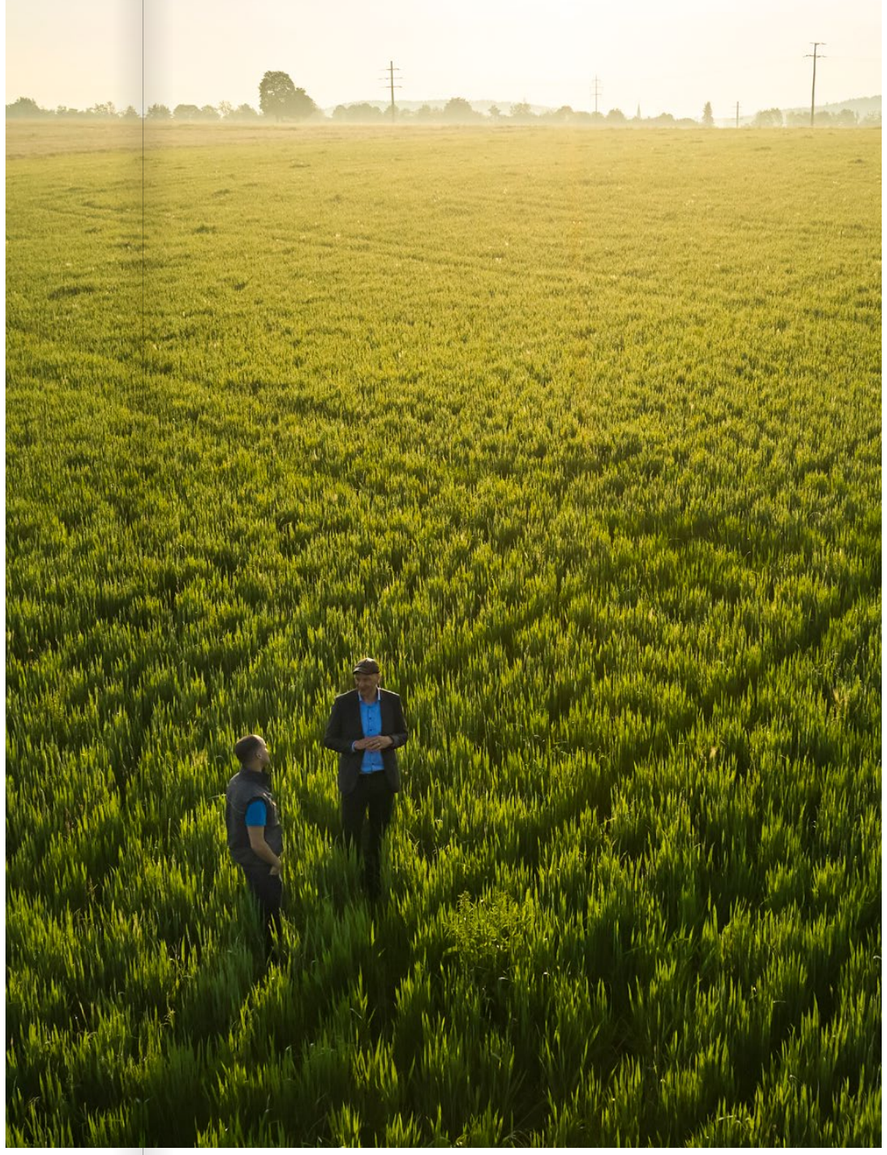
Farmers can play a key role if regulations and infrastructure evolve to incentivize and accelerate the transition from feed crops to food crops. Together, we can advocate transition-focused policies that ease and accelerate the shift from animal farming to sustainable protein production in ways that revitalize rural economies.

The world's leading NGOs can contribute by recognizing and prioritizing the fact that alt proteins can free up massive amounts of land and water for restoration and recovery. As agriculture today is the biggest driver of deforestation and biodiversity loss, it's also our greatest opportunity to change course. A shift to alternative proteins can play a key role in agriculture's regenerative future; and they add much-needed diversity and resilience to our food system in ways that also lessen global health risks.

And finally, what are the key milestones for the sector moving forward?
BF: Two come to mind: 5 percent market share and billions in government support and incentives.

Alternative proteins reaching 5 percent market share is a critical target for the industry. Just this year, the U.S., Europe and China all reached that same 5 percent tipping point with electric vehicle sales. When new technologies hit a tipping point threshold, that signals the start of mass adoption, moving innovations from alternative to mainstream. There's no doubt that getting there will require alt protein meals that reach parity with conventionally made meat in both taste and price.

Securing billions, not just millions, in government funding for alternative protein R&D is another key milestone. Virtually every game-changing innovation in the past century has relied on government support in its early days – the internet, GPS, touchscreens, mobile phones, electric vehicles. And while government funding has increased dramatically in the last several years, alternative proteins will require far greater government support for R&D into production and scaling to reach mass adoption. It is estimated that US$10 billion per year in global public spending on R&D and commercialization is needed to unlock the full potential of alternative proteins. This level of support is certainly more commensurate with the impact of food and agricultural emissions globally.



Alternative proteins – specifically plant-based and cultivated meat – can help write the next chapter for agriculture.

Bruce Friedrich

Bruce Friedrich

Founder and President, The Good Food Institute

Based in Washington, D.C., Bruce serves as GFI's chief thought leader and relationship-builder, working in close partnership with GFI's global teams and food system stakeholders around the world.

Carlotte Lucas

Corporate Engagement Manager, The Good Food Institute Europe

Based in Amsterdam, Carlotte connects with companies and investors across Europe to encourage investment, catalyze innovation and support the sector's shift towards sustainable proteins.

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