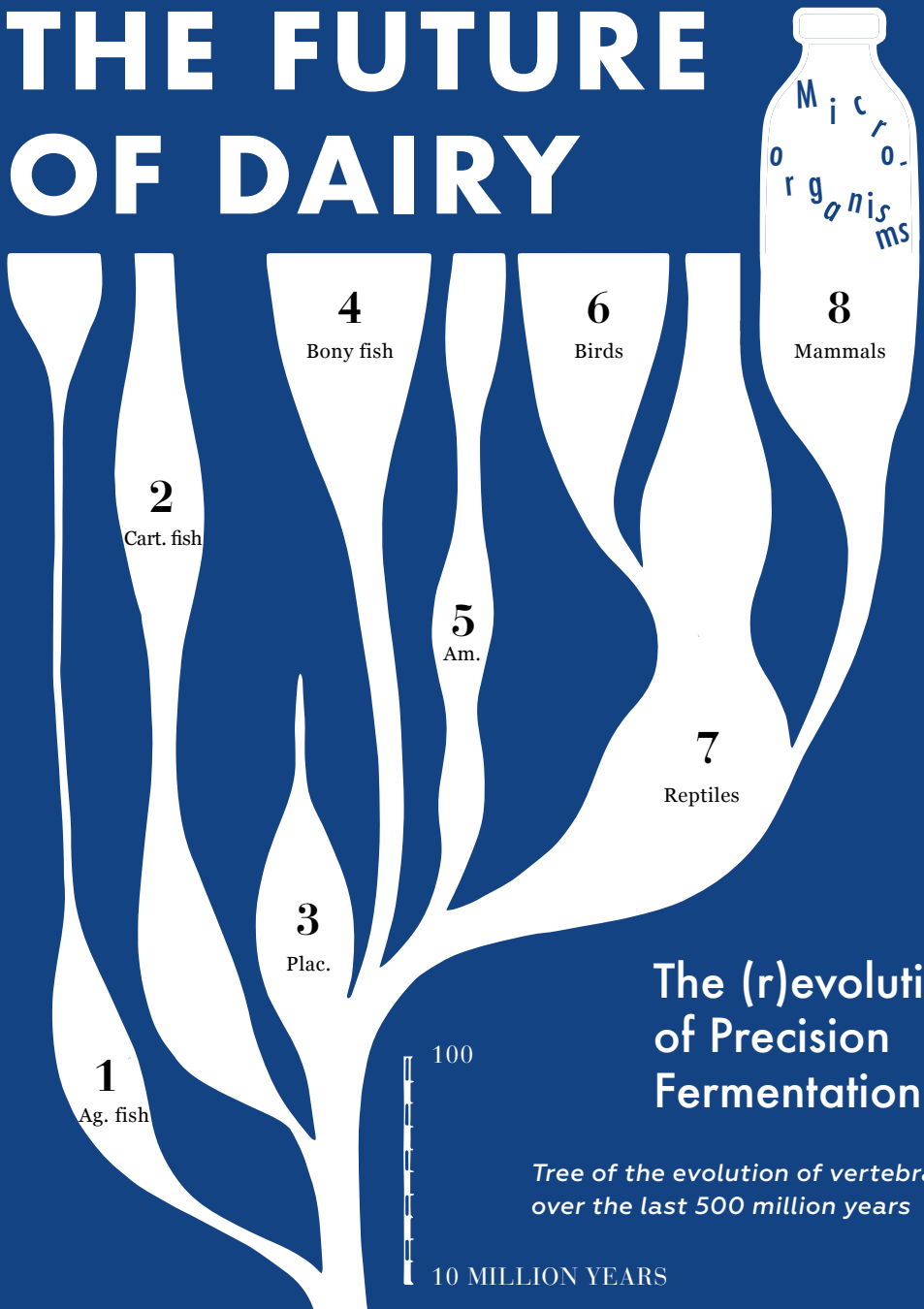
Bon Vivant

THE FUTURE OF DAIRY



The (r)evolution of Precision Fermentation

Tree of the evolution of vertebrates over the last 500 million years

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Stéphane Mac Millan

THE FUTURE OF DAIRY

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When we decided to create Bon Vivant, several challenges appeared to us. Not only we created a company from scratch, but we also faced some of the major issues of our time which is to effectively contribute to the urgent need to meet global environmental needs. We quickly realized that one of the industries that had the most negative impact despite a lot of effort and improvements, on the environment, animal welfare and human health, is the food industry. Indeed, it is a market that has a double stake which is to continue to feed a growing world population with proteins while reducing its impact on the planet. Being French and given the size of our dairy industry, we found that this is where we would have the most impact, precisely in the production of alternative milk proteins produced by Precision Fermentation. In short, cow's milk produced without cows. It is with this ambition that Bon Vivant was born.

Moreover, our mission is also to help the end customers understand what alternative dairy proteins are, to provide transparency around the technology and methods of production, what is behind its regulation for consumption and to serve as a truthful source for its market scenarios. This is why we produced this white paper to explain, give more detail and food for thought about these new proteins and their potential.

Unlike scientific works that speak to a community of experts, this white paper is intended to be read and appreciated by as many people as possible. It brings together data from different sources and shares the lessons we have gathered from countries that are more advanced than France and Europe on the subject.

For most countries today, the production of alternative dairy proteins by Precision Fermentation can contribute to solve some major issues:

• **Food sovereignty**. With an ever-growing population, the risk of insufficient production capacity is significant. According to the Food and Agriculture Organization of the United Nations (FAO), the global demand for animal proteins will increase from 50% to 100% by 2050.

• **Environmental and animal welfare preservation**. In addition to practices sometimes disrespectful of animals, livestock farming is responsible for 14.5% of greenhouse gas emissions and occupies 27% of the land (FAO).

• **Human health**. Globally, after the age of 8, more than 80% of people are intolerant to milk, mainly cow's milk, which is very often due to the presence of the lactose sugar in the milk.

Precision Fermentation-produced dairy proteins are an opportunity to offer complementary healthier dairy products, free of lactose and cholesterol, while preserving the taste and the nutritional qualities of conventional dairy products, without exploiting animals or practicing intensive farming.

Thanks to this technology, we want to enable the dairy industry, in Europe and worldwide, to have a food mix on the model of the energy mix, in which conventional, plant-based and fermentation proteins coexist to meet the needs of the population. And we will achieve it while keeping the taste, the quality, the richness, and the diversity of dairy products, and reducing the environmental impact of the food industry. The Bon Vivant project complements conventional agriculture while preserving the land, the environment, and the animals.

Enjoy your reading!
Hélène Briand and Stéphane Mac Millan

Context

MEASURING THE URGENCY

Today, the technological innovation in food is presented in the context of the climate emergency and the new modes of behaviour that entails. For companies wishing to offer an alternative food, such as non-animal milk protein, the course is clear: to make the project, in all its dimensions (technological, economic, and legal), coincide with the criteria of one or more sustainable development models such as those described in the latest report1 released by the Intergovernmental Panel on Climate Change2 (IPCC). What are the issues behind this mandate?

Heavily industrialized since 1850-1900, humanity has entered the Anthropocene. This term describes how human activity has become the main cause of climate and environmental change. Such an upheaval involves all living organisms and the planet's resources. This is the first time that a geological era is named after a biological entity that has developed on the Earth's surface. It is also the first time that a single species is responsible for a climate change that could be irreversible.

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[1] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA.

[2] IPCC is an intergovernmental body of the United Nations responsible for advancing knowledge on human-induced climate change.

Indeed, greenhouse gas emissions due to human activity are the primary cause of global warming, which continues to increase year after year. In this way, 'Anthropocene' refers specifically to the human footprint. It corresponds to the inclusion of significant changes of human origin in geological time — changes observed in the structure and functioning of the Earth System, particularly in the climate. The scientific community has demonstrated that this new era began in the middle of the 20th century. Researchers in diverse disciplines refer to the Anthropocene to account for the undeniable causality that links human activity to the Earth's current state, to the forces at play and to the future towards which it is heading.

Already, the anthropogenic pressure on the climate is clear to see. Of the twenty warmest years recorded since 1850, when the meteorological archives were established, eighteen have occurred in the last two decades. It is likely that this increase will reach or exceed 1.5°C between 2030 and 2052 if it continues at the same rate. The many effects of climate change are now obvious in all inhabited areas, both continental and oceanic. Not surprisingly, the effects of climate change are not uniform with different parts of the planet unevenly affected. What the scientific data establishes beyond doubt is that an average surface temperature of 1.5°C over the entire globe increases, among other uncontrollable events, the risk of heat waves and precipitation of exceptional intensity. It is therefore feared that warming due to anthropogenic gas emissions since the pre-industrial era (1850-1900) will be felt for a period extending from several centuries to several millennia. It will certainly continue to cause other long-term changes in the climate, such as sea level rise and other disastrous consequences that are currently difficult to predict.

The situation, however, does not need to take such a disastrous turn. The latest IPCC report1 states that if all greenhouse gas (GHG) and other emissions were stopped immediately, warming would not reach, let alone exceed, 1.5°C. This is good news. Even though we cannot put a complete stop to thermal gas emissions, we must nonetheless work to reduce them, as quantified by the Paris agreements. This indispensable reduction gives the Planetary Community a concrete and accessible objective in the near future of one to two decades. Our immediate responsibility is therefore to act to contain global warming within limits compatible with the preservation of the conditions of life on our planet.

But although limiting global warming to 1.5°C is possible within the strict laws of physics and chemistry, it is an effort that is out of all proportion to what humanity has accomplished so far. It requires a change to all aspects of society.

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[1] IPCC, 2018: Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)].

01

FEEDING AND SAVING

Food at the heart of the ecological transition

Because it affects the land, its vegetation, water, livestock and our consumption habits, the food sector is one of the major levers of this transition. As the second main cause of GHG emissions, after the transportation industry, every action that reduces global warming will have important consequences. It is true that technical evolutions during the 20th century have made it possible to feed a large part of the world's population; but an even larger role will be expected from the food industry in the 21st century, namely, "1.5°C models". The common denominator of these models is that they project a reduction in arable or livestock land. This reduction in agricultural land reserved for human food or livestock is made possible by a better exploitation of land for direct yield (human food) or indirect yield (fodder) accompanied by a change in consumption practices.

Since the mechanized and chemical agricultural industry bears a heavy responsibility for the climate's current state and the damage caused to the world's biological diversity the sector is sensitive to these issues. It is true that what geographers have called 'the chemical revolution' has prevented famine in many parts of the world, and countries such as China and India have been able to ensure food security for a considerable part of the world's population. But the use of chemicals in the cultivation process has a strong negative impact on ecosystems and consumers.

It is also a system that faces physical limits: the capacity of soils to regenerate, of livestock to produce milk or meat quotas have reached their maximum despite the efforts of agricultural practices, species selection and nutrition. From the end of the 19th century to about 1950, it is estimated that the average milk yield oscillated around 2000 litres per cow per year depending on climatic hazards. Between 1960 and 2020, this yield increased from 2000 to more than 7000 litres and some animals can produce nearly 20,000 litres of milk per year!

Simultaneously, primary vegetation lands are receding constantly. Water, often used without control, is becoming a scarce element. Let's remember that to produce one litre of milk it is estimated that at least 100 litres of water are needed, a figure which can rise to 1000 litres if we integrate the Water Footprint Network[1]. In short, the over-exploitation of natural resources and the race for purely quantitative productivity (ever more livestock and cereals planted, 50% of which are used to feed them) have led to the current situation where our species is living beyond the planet's means and at its expense. This is evidenced by the fact that each year the Earth Overshoot Day, which marks the date when humanity's demand for ecological resources and services exceeds what Earth can regenerate, is a little earlier: in 2022 it was July 28, in 2002 it was September 19.

[1] The Water Footprint Network is a platform for collaboration between companies, organizations and individuals to solve the world's water crises by advancing fair and smart water use. See www. waterfootprint.org

THE REVOLUTION OF THE SECOND DOMESTICATION

However, even if the Anthropocene, with all its consequences, is now a proven notion, another historical change of considerable scope is emerging: the second domestication. This is a very ancient human activity that consists in selecting wild animals or plants and controlling their reproduction in order to benefit from food and services in the long term. During the Neolithic period, ten thousand years ago, the first systematic domestication took place, that of cereals and animals linked to agriculture. Today, the second domestication, that of microorganisms, is beginning. While the first allowed humanity to master macro-organisms, the second one will allow us to ensure the assistance of microorganisms.

Indeed, an often-neglected component of this first domestication is the vital role played by microorganisms. Microorganisms exist naturally within macro-organisms, breaking down nutrient inputs to create useful substances. For example, the microorganisms in a cow's digestive tract help produce the proteins and amino acids it needs to live, grow, and transform its muscle mass into high-protein food. By selecting livestock and seeds over several millennia, humans have consciously manipulated the evolution of macro-organisms, but also unintentionally manipulated the evolution of the microorganisms they contain.

The daily relationship with microorganisms over thousands of years of experimentation has led to the identification of their power to transform living matter, i.e., the fermentation of foods and beverages in a more direct way. This gradual process is essentially due to early fermentation experiments. In controlled environments such as ceramic pots and wooden barrels, humans slowly discovered how to make many basic foods such as bread and cheese, how to preserve fruits and vegetables, and how to produce alcoholic beverages. Humans were now able, albeit in a rudimentary way, to control the production of food. Over the millennia, until very recently in human history, the pattern of food production remained remarkably stable, based on the lessons learned during the first domestication.

Today, we are on the cusp of the next great revolution in food production. New technologies allow us to use microorganisms to a far greater degree than our ancestors could have imagined. We can now exploit them directly as superior and more efficient units of nutrient production. What is now underway is a new kind of domestication.

The most important ethical consequence is the absolute respect of the animal's existence. It is possible to select and breed microorganisms leaving the animal untouched. For the first time since the transformation of the microorganisms into an industrial product, humanity looks forward to a positive future. Its relationship with the living is no longer that of a dominant species facing 'machine animals'. Thanks to scientific progress, we are faced with a development of historical significance. If, in order to feed itself, humanity no longer needs to exploit animals without regard for them or for the resources that their breeding implies, then the sharing of the world in a true Planetary Community is finally possible.

What is coming is a new kind of agricultural revolution. If we are to believe Eric Schmidt, former CEO of Google, biotechnologies will be to the coming decades what micro-processors have been to the previous ones. Indeed, fast innovation in technologies such as Precision Fermentation and their application to the agricultural world is a huge step forward in the ecological transition of the food sector. It is striking to observe that two of the major documents that structure the reflection on the scientific and economic data related to global warming intersect along the issue of alternative protein biotechnologies:

"Fortunately, there is also good news. Despite the relatively low budget for green R&D, some technologies such as solar, wind, electricity storage, LED lighting, electric vehicles, or animal protein substitutes have progressed faster than expected."[1]

"Furthermore, a range of measures could radically reduce agricultural and land-use emissions and are not yet well-covered in IAM[2] modelling. This includes plant-based proteins and cultured meat with the potential to substitute for livestock products at much lower GHG footprints. Large-scale use of synthetic or algae-based proteins for animal feed could free pastureland for other uses."

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[1] *Les grands défis économiques*, Olivier Blanchard, Jean Tirole, PUF, 2022. *Les grands défis économiques* is a report on the economic aspects of global warming, the fight against inequality and pensions in France. It was commissioned in early 2020 by French President Emmanuel Macron to a group of economists led by Professors Olivier Blanchard, an influential macroeconomist specializing in labor economics, and Jean Tirole, winner of the 2014 Nobel Prize for Economics.

[2] Integrated assessment modelling (IAM) or integrated modelling (IM) is a term used for a type of scientific modelling that tries to link main features of society and economy with the biosphere and atmosphere into one modelling framework.

With a projected world population of 10 billion in 20501 and a demand for animal protein that will increase by 50 to 100%, it seems increasingly likely that one of the pivots of agricultural transition is the production of non-animal protein through the second domestication.

By 2030, it is estimated that 10-20% of the meat, eggs and dairy or seafood consumed in the world will be alternative substitutes2. Of course, there is never a single solution to a problem as complex as that of sustainable human nutrition. With the prospect of feeding the population while limiting the impact on natural resources, the biotechnological revolution must find its place in a set of varied productions likely to suggest new ecological behaviours to the consumer and reduce the carbon footprint. In the same way that the need to rely on an energy mix is now commonly accepted, it is very likely that the same will be true for the development of a food mix. Biotechnologies are a complementary mode of production to traditional modes of production.

In a nutshell, changes in food practices, made possible by the advances of biotechnology, is located on the front line of the transition because it represents the simplest way, for the greatest number of consumers, to alleviate the pressure that our species puts on the Planetary Community.

However, if Precision Fermentation is indeed a technology likely to change the rules of the game, questions naturally arise as to how it works: Basically, how can we produce milk proteins without cows? And, precisely, what is Precision Fermentation?

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[1] *The 2022 Revision of World Population Prospects*, United Nations Secretariat (Population Division of the Department of Economic and Social Affairs).

2 *Evaluation d'impact des mesures prises depuis 2017 sur la réduction des gaz à effet de serre en France à horizon 2030, Boston Consulting Group, February 2021.*

01 — Feeding and saving: food at the heart of the ecological transition

ALTERNATIVE PROTEINS

A taste of the future[1]

"What we see today is only the beginning of the protein transformation. By 2035, after alternative proteins reach full parity in taste, texture, and price with conventional animal proteins, 11% of all the meat, seafood, eggs, and dairy eaten around the globe is very likely to be alternative. With a push from regulators and step changes in technology, that number could reach 22% in 2035.

By then, Europe and North America will have reached the point of "peak meat," and consumption of animal proteins will begin to decline.

By 2035, the shift to alternatives will save as much carbon dioxide equivalent (CO2-e) as Japan emits in a year, conserve enough water to supply the city of London for 40 years, and promote biodiversity and food security

About 13 million metric tons of alternative proteins were consumed globally in 2020, just 2% of the animal protein market. We expect that consumption will increase to more than seven times that size over the next decade and a half, to 97 million metric tons by 2035, when the three types of alternatives will very likely make up 11% of the overall protein market. Assuming average revenues of $3 per kilogram, this amounts to a market of approximately $290 billions".

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[1] *The Untapped Climate Opportunity in Alternative Proteins*, Boston Consulting Group, July 2022.

GLOSSARY OF THE GREEN TRANSITION

Animal-free

A food, cosmetic or clothing product that does not use animals in its production.

Anthropocene

A period in the history of the Earth defined by a change in the climate system and the biosphere mainly due to human activities.

Disruptive innovation

Disruptive innovation is a demand-led technological change that leads to significant system change and is characterized by strong exponential growth.

Climate-smart agriculture (CSA)

An approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and to ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and, where possible, reducing and/or removing greenhouse gas emissions.

Fermentation

Metabolic process that converts sugar

into another chemical substance. Example: alcoholic fermentation of beer or wine.

First domestication

Period dating back to the Neolithic period (10,000 years ago) during which macro-organisms, animal and plant species were selected and reproduced by humans for use and consumption.

Food security

A situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Integrated water resources management (IWRM)

A process which promotes the coordinated development and management of water, land, and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

Life Cycle Assessment or LCA (also known as Life Cycle Analysis):
A methodology for assessing environmental impacts associated with every stage of the life cycle of a commercial product, process, or service. For instance, in the case of a manufactured product, environmental impacts are assessed from raw material extraction and processing

(cradle), through the product's manufacture, distribution and use, to the recycling or final disposal of the materials composing it (grave).

Micro-organism

Living organism (yeast, fungi, bacteria) that can be seen only through a microscope whose metabolism produces, by fermentation, chemical substances such as proteins.

Mitigation (of climate change)

A human intervention to reduce emissions or enhance the sinks of greenhouse gases. Mitigation measures are technologies, processes or practices that contribute to mitigation: for example, renewable energy (RE) technologies, waste minimization processes and public transport commuting practices.

Precision Fermentation

Biotechnological innovation that allows the production of targeted proteins by reorienting the metabolism of microorganisms during fermentation.

Rennet

Coagulant of animal milk extracted from the abomasum (fourth stomach) of young ruminants. Traditionally used in the manufacture of cheese.

Second domestication

Period during which microorganisms were selected and reproduced by humans for use and consumption.

01 — Feeding and saving: food at the heart of the ecological transition

Sustainability

A dynamic process that guarantees the persistence of natural and human systems in an equitable manner.

Sustainable development (SD)

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987) and balances social, economic, and environmental concerns.

02

TECHNOLOGY

Pushing fermentation to the next level

Among the most innovative technologies in the food sector and, as a direct consequence, within the scope of the UN recommendations on reducing emissions from AFOLU, the production of milk proteins by Precision Fermentation occupies an exceptional place. It forms part of several models of sustainable development, and it corresponds perfectly to a need of intelligent re-industrialization based on sustainable Research and Development for de-industrialized countries, including France. Precision Fermentation comes at an opportune moment, with a considerably limited impact on natural resources. It meets the large demand for protein that demographic pressure will place on the food industry for decades to come.

As with all food products, the origin is living organisms. In the 21st century biology has taken a decisive step forward by becoming aware of the beneficial potential of microorganisms. These micro-sized life forms are of interest in inverse proportion to their size. They are ubiquitous companions exploited for thousands of years by humanity. Fermentation, a process carried out by microorganisms, was first used for food preservation. Very early in history, techniques to produce alcoholic beverages from fermented plants also appeared such as beer and wine.

In short, microorganisms (yeasts, bacteria, fungi) are small but powerful. In the course of their metabolism (multiplication and growth) they have the power to transform simple foods into another substance of use, e.g., sugar into alcohol during beer or wine production. By learning about their metabolism, it was possible to control their production capacity and harness the natural process of fermentation.
In 1857 Louis Pasteur completely renewed the concept: since all active substances come from living nature, fermentation is a work of the living. His contribution was decisive because before him, fermentation was not associated with the living but with

its decomposition. In his eyes, fermentation was a fundamental mechanism of the chemistry of life. More precisely, he discovered that micro-organisms could transform sugar into other substances by a process that is largely controllable.

Precision Fermentation is responsible for well-known substances which are vital in several relevant industries including pharmaceutical and food. For years insulin used for the diabetes treatment was extracted from pork or cow's pancreas and presented several secondary effects to human health. Nowadays, insulin is produced through Precision Fermentation. Another example is Rennet, a by-product of cattle breeding and an essential protein. Extracted from the abomasum, the fourth stomach of the calf, it was traditionally used in the manufacture of cheese. Currently a vast majority of the cheeses we consume have been made using rennet produced by Precision Fermentation.
Independent of breeding animals, Precision Fermentation allows for the production of multiple substances, often more valuable for human health (less allergen, greater purity; Figure X – Rethink X).

Source: rethinkX

Precision Fermentation is a modern method, but it is not at odds with the traditional knowledge that has allowed mankind to tame microorganisms in an empirical way, by making beer and wine for example.
When we investigate the heart of the manufacturing process, we can see that it relies on a natural biochemical process which scientists re-orientate. It exploits the power of microorganisms' metabolism to convert sugars into proteins and it does so in a very precise way, by targeting substances of interest.

This is a remarkable engineering of a microorganism's function, and it gives rise to the production process of non-animal milk proteins in **four phases**.

DESIGN OF THE MICROORGANISM'S GENOME

1

The design phase consists in inserting inside a microorganism's genome (yeast, bacteria, fungi) the DNA sequence of milk proteins. Once the DNA sequence is integrated into the microorganism, the biological tool is built, and the microorganism can convert sugar into milk protein.

In summary, through these genetic modifications, we are simply diverting the ability of a microorganism to produce a natural protein to produce specifically the milk protein.

PRECISION FERMENTATION

2

The designed microorganism is than fed with mainly sugar, water, minerals, and vitamins inside a fermenter
This bioreactor is therefore the place of growth and multiplication, where the microorganisms content increases as the sugar content decreases while the milk proteins are produced. The proteins are either produced inside the microorganism or excreted into the fermentation media. Bioreactors also allow the regulation of essential parameters such as temperature, pH, agitation and maintain the microorganism growth and the protein production in highly controlled and optimal conditions. A tank can reach an average volume of 200m3, that is to say a container of 5m wide and 13m high. This makes it an artifact comparable to a beer tank in a brewery or a wine vat in a winery.

At the end of the fermentation period, which lasts on average between 48 to 150 hours, what does remain in the fermenter? A biomass consisting mainly of microorganisms, its quantity is multiplied by 100-1000 during the fermentation and represents at the end of the process 5-35% of the total volume. The rest is a suspended liquid containing the culture media metabolic residues, water and the milk proteins.

02 — Technology: Pushing fermentation to the next level

FILTRATION

3

Next comes the separation phase of the microorganisms and the proteins of interest. This is the most important of the 4 phases because it allows the recovery of the milk protein and the removal of any trace of DNA and yeast's debris.

This precision is more than a terminological nuance because, in the long run, it is not a GMO itself which is produced but a product resulting from GMO like many other products already present on the food market. It should be noted that the efficiency of these separation techniques, commonly applied in several sectors of industry, has already been validated, particularly in the pharmaceutical and food-processing fields. By using very high precision filters, the milk proteins are filtered and retained, and the residual impurities are removed during cleaning and washing operations.

This phase of the production process is completed with the removal of all moisture by drying in a tower. The result is a milk protein powder ready to be used in the production of food and other dairy products.

CREATION OF LACTOSE-FREE AND ANIMAL-FREE DAIRY PRODUCTS

4

The basic product that is presented in this last phase is therefore an ingredient and dairy substitute perfectly suited to the preparation of food for human consumption and equivalent to proteins from animals. It is important to remember that although genetically modified organisms are used in Phase 1 in order to target the production of milk proteins, the final product is not a GMO. It has all the nutritional, taste and functional values of cow's milk protein and is suitable for all its uses. The nutritive values are enhanced by the high degree of purity permitted by the filtration step.

This use is based entirely on the properties of the two main milk proteins: casein and whey protein, which are subsequently combined with plant-based fat sources, mineral salts, etc. to make complete and as nutritive as dairy products.

In short, the production of milk proteins by Precision Fermentation is a powerful technology which meets the growing need for protein for human consumption. With it, the industry can count on a sustainable supply of milk proteins. The functionalities of the milk proteins are the same and already present in many food recipes ranging from classic dairy products to the complementary areas of nutrition and health for seniors and children.

CASEIN AND WHEY

The essential amino acids content that makes up milk corresponds to 39%. Caseins are proteins that constitute a major part of the nitrogenous components of milk with 34% essential amino acid content. Whey proteins have a strong nutritional interest because of their high composition in essential amino acids (43%). The most important are beta-lactoglobulin (ß-LG), alpha-lactalbumin (□-LA) and glycomacropeptide (GMP). This makes it a high-quality protein source for human nutrition.

From a nutritional point of view, casein and whey protein are complementary: unlike casein, which is absorbed gradually and is therefore called 'slow protein', whey protein passes more quickly through the stomach. They can therefore be considered as 'fast' proteins, leading to an immediate increase in the amino acid content of the blood plasma. By reducing its formula to these two proteins only, the milk proteins obtained by Precision Fermentation contains no lactose, no animal fat, no animal hormone residues, and no trace of antibiotics.
In addition to the nutritional interest, there is an important functional interest: whey proteins have a foaming and emulsifying capacities which allows them to mix with fats. This property plays a determining role in what the phenomenology of taste calls 'mouthfeel.
Casein, thanks to its ability to coagulate in the presence of rennet or in an acidic environment, is the basis of cheese making.

Produced by Precision Fermentation, whey, and casein, therefore allow for the creation of dairy products without the use of animals and offer, in strict parallel with cow's milk proteins, essential organoleptic properties:

- SAME **TEXTURE**
- SAME **TASTE**
- SAME **NUTRITIONAL POWER** AS THE ANIMAL PROTEIN

THE TIME FACTOR

Phase 1 of the selection of microorganisms takes between 6 months and 5 years, depending on the optimization of productivity and readiness of the strains. Phase 2 and 3, the development of the process and purification of the protein, requires 6 months to 2 years. On the administrative side, registration, and regulation on the administrative side, takes between 1 and 2 years depending on the country.

In its total production, this is a technology which was taking 5 years to develop before 2018. It has become faster thanks to scientific advances that have improved the tools used in the laboratory and industrial scale. As for Precision Fermentation, it is a green technology increasingly used in many fields such as pharmaceutical, cosmetics and now food. Currently, it only needs 2 to 3 years to become effective.

02 — Technology: Pushing fermentation to the next level

FEED AND SAVE

Precision Fermentation is an innovative biotechnology that meets the growing need for proteins without compromising the environment, pleasure, taste, or animal welfare.

The interest in milk from a non-animal origin is to meet the demands of milk processing by producing an ingredient with high added value. This alternative milk production process has a lower impact on the planet without compromising the taste, texture, and nutritional value for the consumer.

This biotechnology is circular since even its by-product is used. During the final processing, the genetically modified elements are neutralized by a thermal process that leads to the destruction of the DNA. Thus, the final residue (biomass) can be converted into biogas or re-injected into innovative agro technology such as animal feed. The inclusion of the Precision Fermentation process in a circular technology is an essential component of its green credentials.

Since the environmental footprint of the whole process is almost zero, there is every reason to consider milk proteins obtained by Precision Fermentation as a clear progressive step in using biotechnology for sustainable food. Companies developing this process are bound to experience strong growth in the coming decades.

03

INTEREST

Advantages of applying
Precision Fermentation to dairy

LIFE CYCLE ASSESSMENT

In the case of Bon Vivant, it is a working document for auditing purposes that was carried out independently by Lorie Hamelin, professor, and holder of INRAE research chair on sustainable transitions towards low fossil carbon use, and followed methodologies set out by the European Union. It is based on a basic premise: milk produced by cows in Europe[1].

These data were compared with the impact of Precision Fermentation if Bon Vivant produced 2160 tons/y of milk protein (80% pure). As Bon Vivant only produces the milk protein and not per se milk, to be comparable to cow-based milk it was decided to add water, sugar, plant-based fat, and minerals into the LCA model.

The result, according to the 15 impact criteria, is that if Bon Vivant produced this quantity using its process, it would correspond to 65,662 tons of "animal-free" milk by 2028. In terms of climate change impact, this means that we would be able to save:

-92%
on land use (Pt)

-96%
on climate change (Kg GHG eq)

-99%
on water scarcity (m3 depriv.)

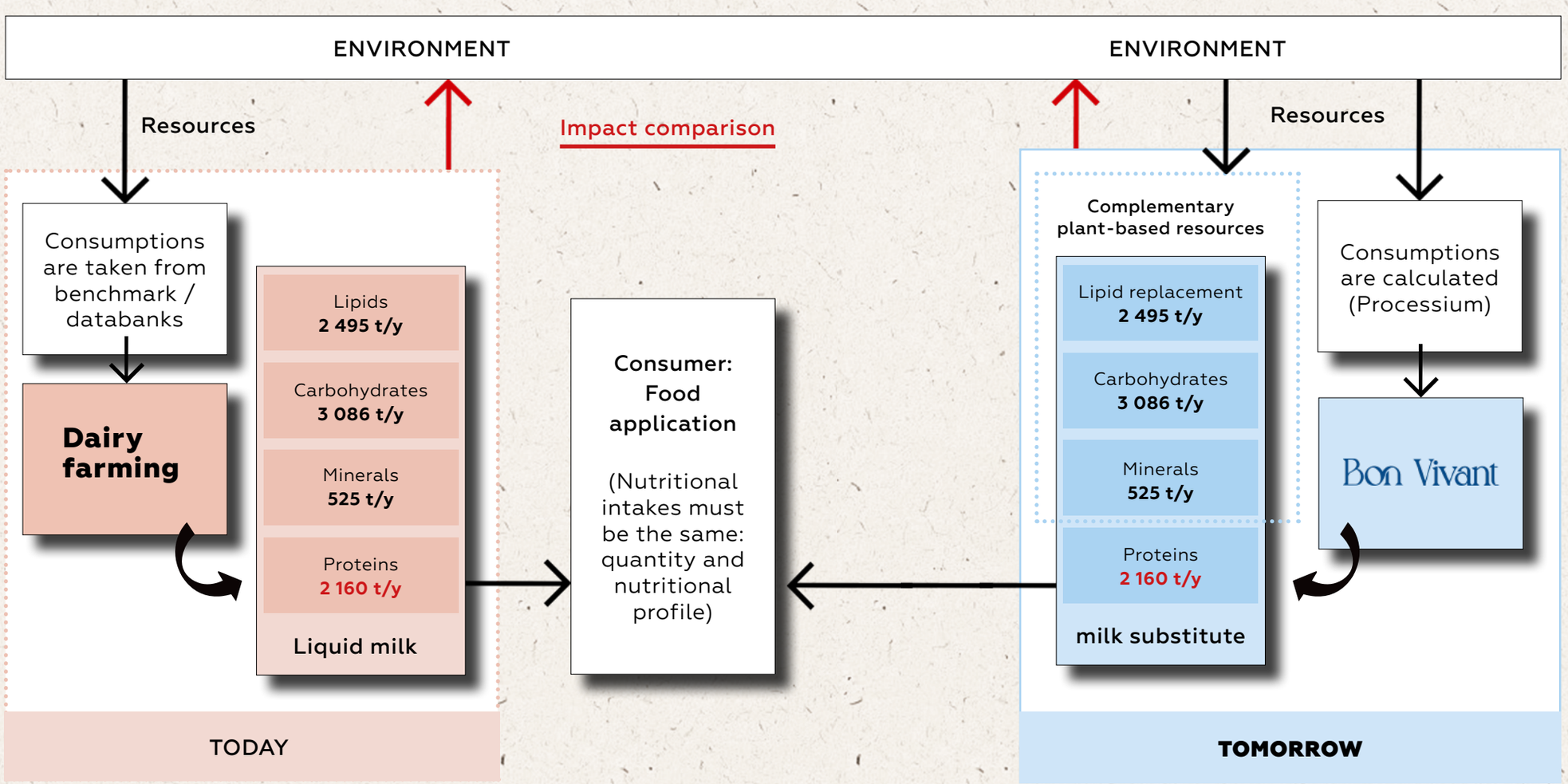
Finally, at the end of the production process, the ultimate residue (biomass) can be converted into biogas or re-injected into innovative agro technology such as pet food nutrition.

[1] The ecoinvent Database, a Life Cycle Inventory (LCI) database that supports various types of sustainability assessments. See www.ecoinvent.org

03 — Interest: Advantages of applying Precision Fermentation to dairy

Latest official data with the input scheme:

COMPARISON OF BON VIVANT LCA VS CONVENTIONAL MILK LCA OVERVIEW[1]



[1] Data taken from a report by L. Hamelin's Lab, Lorie Hamelin, professor and holder of an INRAE Research Chair on Sustainable Transitions towards low fossil Carbon use.

This LCA was made at the request of Bon Vivant and is based on the figures of the Bon Vivant process.

DIVERSITY IS THE KEY TO TRANSITION AND SUSTAINABLE BALANCE

It is in parallel with conventional or local 'terroir' production that Precision Fermentation can make the most of its many assets. The nest idea is that of respecting diversity, including at the level of dairy production.

Far from wanting to take the place of traditional producers, the milk protein obtained by Precision Fermentation is part of a food mix. In terms of food supply as well as ecology, what counts is diversity.

A NEW CYCLE OF FINANCE

The circulation of capital which accompanied the industrial revolutions was, until now, a one-way street: capital goes to capital, money goes to money. With the transition economy which the climate emergency requires, money becomes a resource like any other. The money invested in Precision Fermentation biotechnology will not only turn a profit; it offers the possibility of redirecting the money which no longer goes into arable land or livestock structures in the ecological transition. Even in terms of finance, circularity is the signature of new forms of production in the innovative food industry.

Non-animal milk production is capable of meeting precisely two demands: that of an ambitious transition to mitigate the impact of climate change and that of more efficient food production to feed humanity.

THE NEED FOR A 180° CHANGE TO PRESERVE THE PLANET

We are on the verge of the most profound, rapid, and significant change in food and agricultural production since the first domestication of plants and animals ten thousand years ago. At the time of the first domestication, in the Neolithic period, the real danger was the shortage of food. By domesticating living species, mankind has learned to avoid this risk by building up reserves. Today, we are producing food in a damaging and unsustainable way: the consumer has become aware of the individual impact of food on the planet and the consequences of his way of eating on his health.

"While a growing population benefits from an average increase in its capacity to consume, the demand for food products is exploding. At the same time, the limits of nature are becoming more and more concrete. The global community, without exception, must therefore make a collective intelligent effort to build a circular economy centred on food."[1]

[1] *The food revolution, The future of food and the challenges we face*, UBS Report, July 2019.

It is clear that the main disruptive force in stopping climate breakdown is consumer behaviour. People are demanding a new way to produce food and are driving certain industry directions through the choices they make. The primary cause of this unprecedented influence is that the technology to revolutionize the food system already exists. Of course, a big step has yet to be taken to satisfy the trends that are emerging and to transform food behaviours.

At a time when consumers want to get closer to what they eat in every sense of the word, the material conditions of their lives are increasingly keeping them away from it. Despite the desire to eat 'locally', a single litre of milk, for example, travels a long way before reaching the consumer; sometimes it is first reduced to powder and then rehydrated to be reincorporated into the dairy products that will eventually be consumed. These mass food requirements are subject to industrial or commercial logics which put a brake on the consumer's desire to eat healthily and with respect for the planet. Moreover, they still delay the implementation of adequate responses to this crisis.
The societal reflection and sensitivity on these issues correspond to what many observers refer to as 'mindful eating'. An example of the growing influence of 'mindfulness' in food practices is the need, strongly expressed by consumers, to substitute, in their regular way of eating, protein of animal origin with protein from another source, vegetable or alternative.

Times are changing, in an irreversible way. The need for protein is increasing like never before and at the same time the origin of acceptable proteins is pivoting on its axis. It is pointing in a direction that tends to move away from the domesticated animals on which we have always relied. And nobody has the desire or the means to consider the breeding and use of other sensitive species as an inexhaustible source.

03 — Interest: Advantages of applying Precision Fermentation to dairy

Is the new consumer ready, however, to adopt a diet derived in part from biotechnology?

A study published in October 2022, signed by the French CNRS and the Centre for International Cooperation in Agronomic Research, looks at the plate of the future. Projections show that the average individual consumption of meat will be divided by three, and that of animal milk by 1.4 compared to today.

"Some consumers have already adopted this diet, which consists of reducing their consumption of animal proteins by half without suffering from deficiencies", acknowledges Carine Barbier, an environmental economist at the CNRS and co-author of the report. In this scenario, the protein source of animal origin is only 49% and dairy products are mostly substituted by non-animal milk proteins. The clearest result of this study is therefore to underline the desire for change in consumer habits. They are ready to adopt a diet in which the protein source will be alternative, especially in the field of non-animal milk proteins obtained by Precision Fermentation.

[1] *The food revolution, The future of food and the challenges we face*, UBS Report, July 2019.

Another study conducted by the Hartman Group in 2022[1] demonstrate a raising environmental awareness and will to consume in a more sustainable way from end customers:

• 69% of American consumers acknowledge a need for meeting our society's nutritional needs with fewer resources (energy, water, carbon), 5 points more than in 2019. Another striking fact: younger generations are the most convinced this should be achieved (74% of millennials).

• To do so, science is deemed a good option: 61% of consumers believe science and technology are our best hope to address climate change (67% of millennials). 60% of Americans believe that scientific and technological innovations can make food more sustainable (64% of millennials) and 56% more healthy (62% of millennials).

• As they feel concerned, they are more and more ready to change their habits: consumers are increasingly concerned by the impact of their lifestyle on the environment, and 52% of them are willing to drastically change their lifestyle to live in a more environmentally friendly fashion, 8 points more than in 2019.

• Consumers are already changing their diet and habits: 35% of American consumers like trying foods produced in an innovative way; and 50% of them look for products from companies that prioritize sustainability and animal welfare.

THE NEED FOR EDUCATION ON PRECISION FERMENTATION TO INDUCE TRUST AND BUYING

For this 180° change in our food production habits to happen food industrials have a major responsibility in explaining pedagogically to customers what Precision Fermentation is. This effort on transparency is the cornerstone to build trust and trigger the rapid adoption that we need if we want to collectively meet our net-zero objectives.

[1] *Hartman Group white paper, page 5 & 6*

Again, the Hartman Group study[1] gives us a good idea of the importance of communication in driving change in the food industry:

• Pedagogy increases the purchase intent. When being presented with a brief description of the process, the share of consumers likely to purchase precision fermentation issued products switches from 43 to 56%. Precision fermentation has a lot to gain from pedagogy.

• The main aspects on which consumers should be reinsured are taste and health issues. When asked about what they would need to know to try precision fermentation, the three main issues raised by consumers are safety (60%), good taste (59%) and healthiness (53%)

• Pedagogy about environmental and animal welfare benefits boosts purchase intent significantly. Learning a little about precision fermentation's benefits for the environment raises purchase intent by

PRODUCING BETTER AND GENERATING WEALTH FOR ALL

No significant progress is possible without guarantees of efficiency in production. However, the least efficient and most economically vulnerable sector of the world food system is livestock. The products derived from cows, meat, and milk, will be the first to feel the disruptive impact of the new needs of modern food. Are new technologies likely to change the configuration of food production in the coming decade?

[1] *Hartman Group white paper 2022, page 7, 8, 9*

RESOURCES There have been unexpected advances in non-animal protein production in recent years. Precision Fermentation seems to effectively combats the waste of an essential and already strategic resource: the water. It considerably reduces the use of arable land for livestock production. It uses another source of feedstock, sugars, that doesn't not compete with livestock sector. It lowers the cost of the carbon and energy bill in the food sector. It contributes to the global health of humanity, which has an increasing need for proteins.
In short, it provides a tailor-made answer to the question of food efficiency. Thanks to it, among other elements of a food mix, the major agricultural paradigm shift away from high carbon food production is within reach, made possible by the technologies of the Second Domestication.

THE WASTE Intensive farming is characterized by an inefficient use of land, water, time, and money that also contributes to several environmental and human health impacts. Leaking and overflowing holding tanks and excessive application of manure as fertilizer cause eutrophication (artificially enriched water) in nearby aquatic habitats, resulting in toxic algal blooms, anoxic conditions (total depletion of oxygen in the water), fish kills, and habitat destruction. Faecal bacteria accumulate in surface and groundwater, contaminating water which can be used for drinking or irrigation. Particulates from manure spraying on agricultural fields are also a significant health problem and nuisance to people living near farms.

03 — Interest: Advantages of applying Precision Fermentation to dairy

It should be noted that there is no manure created by modern food production because there are no animals involved in the process. An initial study[1] estimates that a product made from Precision Fermentation generates 92% fewer pollutants than a comparable animal product.

PRODUCTION COSTS The cattle industry is very resource-intensive, with huge amounts of feed crops, land, water, and time devoted to the production of animal-based foods. Currently, farmers essentially raise a whole cow before breaking it down into specific products, such as milk, steak, leather, or collagen. The system is about to run into its own limits in terms of efficiency and resource management. There is little room for improvement in production costs. Over the past 30 years, there has been little improvement in livestock feed and reached a "plateau" of productivity" due to a genetical potential that have been achieved. On the contrary, with a technology such as Precision Fermentation, it is assured that the cost of production will continue to fall considerably. One of the advantages of the process is that it produces only the precise number of individual molecules of interest needed. We have not yet achieved and discovered all the power of microorganisms.

In short, just as the first domestication, that of macro-organisms, has undergone considerable evolution, especially during the industrial period of the 20th century, the second domestication, that of microorganisms, is still in its infancy. No one can say today what our world will look like when new techniques utilizing microorganisms will lead to increasingly sophisticated fermentation or purification processes.

So, it should come as no surprise that modern means of production will be about 10 times more efficient at converting directly sugars into proteins. Because a cow needs energy from the feed it consumes to maintain and develop its complex physical structure over time before producing proteins (meat/milk). With microorganisms, by contrast, less feed needs to be consumed to grow and produce proteins. This means also less time spent on feeding the livestock, with its rumination and methane production phases. Less land is needed to grow the grain on which the cattle are fed. Less water is used, and less waste is produced. The savings are considerable: 10 to 25 times less raw materials, 10 times less water, five times less energy and 100 times less land.[1]

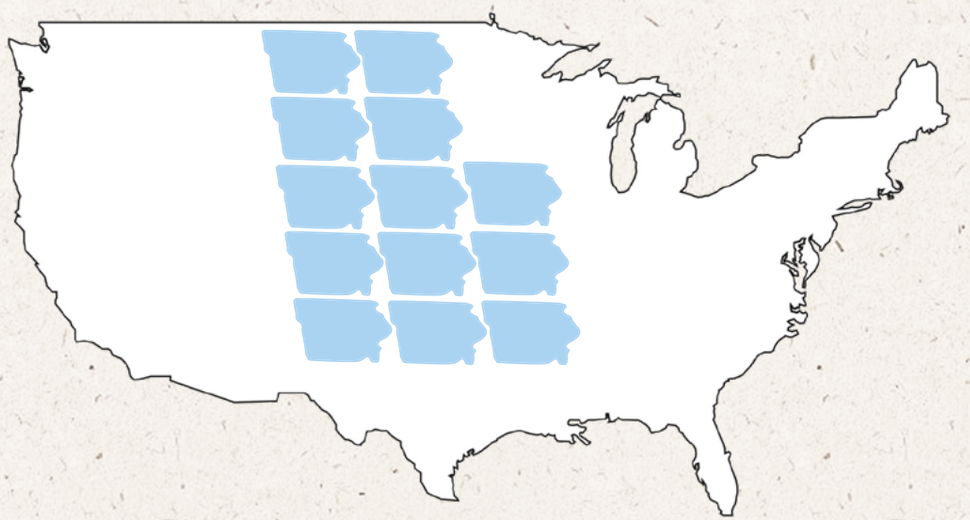
[1] *Rethinking Food and Agriculture 2020-2030, The Second Domestication of Plants and Animals, the Disruption of the Cow, and the Collapse of Industrial Livestock Farming,* A RethinkX Sector Disruption Report, Catherine Tubb & Tony Seba, September 2019.

SUPPLY CHAIN COSTS

The cultivation of microorganisms, complementary to conventional production, will also bring with it an entirely different food production system that won't compete each other for the same resources. Production now moves from the field to the fermentation tank. The reduction of the supply and value chains currently associated with cattle production is expected to significantly reduce costs. Fermentation-based production allows to localized production units which are much more efficient, virtually eliminates waste and reduces the transportation burden. This will result in a more rational distribution network, with cheaper and more stable end-product prices as well.

Existing livestock supply chains rely heavily on extensive infrastructure, large-scale farms, and slaughterhouses. With new food production structures, packaging facilities and distribution intermediaries, will become largely redundant and thus tend to disappear as the boundary between producers, wholesalers and retailers blurs. Food production is on the move. It is moving from large, peripheral agricultural areas to smaller, easily accessible urban areas. Another asset is the possibility for countries currently without milk production, for structural climatic reasons, to benefit from Precision Fermentation technology. This would have the benefit of reducing costly, carbon intensive road or sea transport.

THE IOWA PARALLEL[1]



By 2035, about 60% of the land currently being used for livestock and feed production will be freed for other uses. This represents one-quarter of the continental USA The opportunity to reimagine the American landscape by repurposing this land is wholly unprecedented. These 485 million acres equate to 13 times the size of Iowa.

[1] *Rethinking Food and Agriculture 2020-2030 [...]*, RethinkX, 2019.

04

THE MARKET FOR ALTERNATIVE PROTEINS:

An international, financial and political race

The main alternative protein market is currently driven by three countries: the United States, India, and Israel. One might expect these three bridgeheads to have points in common that could inspire other countries to develop this sector in their turn. Let's try this comparison.

WHY THEM?

They are three parliamentary democracies. But whereas the USA is a transcontinental state in North America, India is a sub-continental state in South Asia and Israel is a Mediterranean state in the Near East without a continental dimension. Their surface areas also differ greatly, with more than 9 million sq. km for the USA, more than 3 million sq. km for India and barely 22,000 sq. km for Israel.

In terms of population, the ratio is reversed in favour of India, with 1.3 billion inhabitants, compared to 331 million for the USA and a little over 9 million for Israel. From the point of view of economic development, the USA has been highly industrialized for more than a century, whereas India is a newly industrialized country and Israel — born as a state at the same time as the Indian subcontinent — reached what one might call immediate industrialization in the years following its creation. One point of convergence, however, is shared by several other countries that are not yet prominent in the alternative protein market: confidence in advanced technologies.
It is as if the differences in scale, structure, historical and cultural

context could not account for the leadership role of these states, which are too different to be comparable.
To understand their position, we must go further and question the way in which they perceive their position in this market, and above all, what justifies, in their eyes, their leadership.

3 LOGICS OF SUCCESS

THE USA: THE FORCE OF NATURE

A report by Good Food Institute (GFI) bluntly answers the question of USA market perception and leadership:

"Traditional USA strengths in agriculture, food processing, and biomedical technology, as well as some of the best research and development capabilities in the world, give the USA a natural advantage in what promises to be a global race for innovation.**"**[1]

The heart of the argument is that in this new alternative protein sector, the USA economy will expand its natural dominance. It is, in other words, a form of hegemony based on the nature of the American people, their capacity for innovation, hard work and investment. In ordinary words, we find the well-known confidence of the United States in the global role it plays, in high-tech agriculture as elsewhere. It is this factor that explains their position of superiority.

[1] *American National Competitiveness & the Future of Meat, Why the United States needs to build up a domestic alternative protein industry*, Good Food Institute, 2022.

Of course, American certainty of excellence is based on something. The United States is at a crossroads in protein policy. In recent years, alternative meats, eggs, and dairy products have gained media attention and market share. A few very active players set the scene: Plantible, Impossible Food, Beyond Meat, Perfect Day or Memphis Meat.

Today, 'cellular agriculture' is a factor that could upset the economic balance because of its considerable development potential. Reproducing, thanks to biotechnologies, animal by-products such as meat or milk, without the need to raise or slaughter animals, is a revolution in food. The foreseeable benefits are enormous: economic growth and stronger national competitiveness in global markets, new tools to meet climate and biodiversity goals, and mitigation of pandemic and antibiotic resistance risks.

It is therefore quite natural that alternative proteins, already on the American domestic market, seem destined to become the food of the future. It should be noted that the USA is the first country after Singapore to have given its approval, through the FDA, for the commercialization of cellular meat, the beneficiary of this important advance being the start-up Upside Foods.

The strength of the protein sector, in addition to technology, is the new consumer trends. The USA economy, as we know, is used to projecting itself into the global market as if it were a natural extension of the domestic market. In this context, it recognizes that the world's population is growing in number and wealth, which means an increased demand for protein-rich foods. At the same time, consumer concerns about personal health and environmental sustainability are driving an openness to animal-free options. Among the growing market segments, these expectations are particularly relevant to middle-aged and younger consumers who will dominate future demand. These factors have led to an

explosion of investor interest in alternative proteins. The year 2021, for example, saw record transactions as production capacity indicated strong growth. According to GFI, the total amount of capital raised in this sector in 2021 was $5 billion.

America is therefore well positioned to benefit from the protein transition. In the short to medium term, both alternative and conventional proteins can grow in an expanding market. But alternative proteins are growing faster and, over time, are likely to capture more and more of the food market. As investments follow or anticipate consumer spending, the effects will ripple across the value chain, generating real impacts for local communities throughout the US and beyond.

INDIA: THE VITAL NEED

In a very different context, the Indian perception of alternative proteins' prevalence in the subcontinent is also unambiguous. A pragmatic approach provides the key to understanding this. The Indian food policy of the last few years is primarily based on an observation: the agriculture of the green revolution (or chemical revolution) is out of breath. Many farmers, in debt, are committing suicide. The figures are terrifying: according to a report by the Indian administration relayed by the British channel Sky News, more than 256,000 Indian farmers committed suicide between 1995 and 2010.
A considerable mass of workers is employed in the agricultural sector while the industry lacks the manpower to develop. The yields are not up to the needs. For many Indian entrepreneurs and investors, the situation has become unacceptable.

04 — The market for alternative milk proteins: an international, financial and political race

A SECTOR SUPPORTED BY GOVERNMENT INVESTMENT IN THE UNITED STATES[1]

House Representative Ro Khanna (Democrat for California) led a request supported by 10 members of Congress to the USDA to increase funding for alternative protein research. This is the latest major policy step in support of alternative proteins after the considerable step forward in FDA approval of cell meat.
In a December 17, 2021 letter Representative Khanna and other members of the House Agriculture Committee asked USDA Secretary Tom Vilsack to include alternative protein research in USDA's FY 2023 budget request.

The letter also requested that $50 million of the Coronavirus Relief funding be allocated to alternative protein research to "improve the sustainability and resilience of our food systems" and "create new economic opportunities for American farmers, new benefits for consumers, and help reduce agricultural emissions."

[1] www.vegconomist.com/politics-law/congress-funding-alternative-protein/

Another observation recognises that the Indian population is the largest on Earth and will probably remain so in the decades to come.1 Managing to feed 1.3 billion people properly (i.e., with proteins) is a real challenge.

Today, more than one child out of five (22%) is stunted, even in the richest Indian households. This rises to one in two children (51%) in the poorest households. In total 38% of children under the age of four are affected by malnutrition, according to a UNICEF report on The State of the World's Children (SOWC). In fact, India, despite its emerging economic power, is the third country in the world with the highest rates of underweight children, just behind Djibouti and South Sudan.

India therefore sees the development of alternative proteins as the answer to a vital need. More commonly known as 'alternative proteins' around the world, the term 'smart protein' is preferred in India where it resonates strongly with consumers. It encompasses the vegan, cultured and precision-fermented meat, egg and dairy sectors. The whole sector is growing exponentially and is set to explode if the large amount of investment it attracts is anything to go by. As Indian consumers are much more open to these new products than Westerners, and the Indian demography is not comparable to that of Western countries, everything seems to confirm the immense potential of the Indian cultured meat and alternative milk protein industry.

In short, India's conventional agriculture is reaching its structural breaking point and is not, on its own, able to supply a market of

[1] According to INED, the French National Institute for Demographic Studies, India will be the most populous country in the world in 2050 with 1.7 billion inhabitants.

more than one billion consumers with traditional proteins. The significant development of the alternative protein sector is an indication that the Indian economy is impartial in banking on its domestic market's unprecedented size and on biotechnology to meet its vital need for protein.

Ananta Hempworks Solutions (hemp seeds as an active source of fat, protein, sugar, fiber and minerals), AyurNosh (gluten-free vegan ready meals), Mountain Tribe (kombucha), Nutriplay (100% organic diet snacks to ensure balanced intake and fight obesity), Only Earth (oat, coconut and almond drinks, rich in vitamins, protein and fiber) Rooted Active Naturals (dietary supplements based on mushrooms and plant principles), Saral Proticons (plant protein powder), Snill Burger (vegan burgers), Upbites (snacks based on seeds rich in proteins and minerals guaranteed without chemical inputs), Wellversed (line of plant-based protein foods, general and sports nutrition), are often ranked as the ten most dynamic start-ups in the sector.

ISRAEL: EXISTENTIAL SECURITY

Israel's understanding of its leadership position in the alternative protein market is deeply linked to the country's recent history and the challenges it faces simply to exist.

The Israeli position in the food sector has the advantage of clarity. Without a proactive policy of food sufficiency, the very existence of the State of Israel is threatened. If "Israel leads the world in food technology," said Nir Goldstein, president of the Good Food Institute Israel, it is because it is a matter of survival for the country.[1]

[1] *Times of Israel*, January 2022.

Indeed, more than any other state, Israel must be able to count on food sovereignty and self-sufficiency, which is primarily intended to allow its population to feed itself despite the almost permanent tensions at its borders. In this context, a strong food industry can guarantee the country's food security and become a strategic asset for Israel.

According to a GFI report published in March 2022, the alternative protein sector — part of the dynamic food technology industry — would have grown by about 450% in 2021 in Israel compared to the previous year. Israeli start-ups in the sector are also reported to have raised some $623 million.

This is understandable as the food technology industry ecosystem is among the most dynamic in the world. It includes nutrition, packaging, food safety (control and standards), processing systems and new ingredients, in addition to alternative proteins. The latter alone includes plant-based alternatives for meat, dairy and eggs, aqua cultured seafood, insect proteins and fermentation products and processes.
According to the report, 11 new alternative protein companies were founded in Israel in 2021 — 6 aqua cultured meat and seafood companies, 4 plant protein companies and 1 Precision Fermentation company.
The report indicates that the significant growth of the Israeli alternative protein sector would be linked to massive investments in companies whose products are close to commercialization and whose diversified offerings would allow them to target global markets.
This movement of capital, which consists firstly of moving towards companies whose innovations make it possible to ensure the country's food security and then to conquer new international markets from a strategic perspective, truly characterizes the Israeli paradigm in the development of food biotechnologies.

An example? Announced in early 2022, the second largest fundraising by an Israeli food technology start-up went to Remilk, a producer of animal-free milk and dairy products through Precision Fermentation, like Bon Vivant, for $120 million.

THE PARTICULAR CASE OF EUROPE

Europe offers a contrasting landscape in the production of alternative proteins. Because of its historical position as a leader in agri-food, one might expect to find it at the forefront of the leading sectors in food biotechnology. This is not the case. It seems that until very recently, it had difficulty in grasping the issue of protein transition.

In response, several answers present themselves. Should regulatory obstacles be blamed? It is true that the administrative structures of the European framework piles up the levels of reflection and decision, which lengthens the inevitable back and forth between the proposal of companies and the decisions of the Commission or the member states. It is not always clear who has the final say in authorizations. Yet the law is a principle dear to Europeans and has always accompanied innovation. There is therefore no reason to believe that food biotechnologies are only encountering legal inertia in Europe.

Should we consider, then, that the Old Continent's market is not ready? This would be to miss certain features of the global food market that are clearly expressed in Europe. For example, European consumers are also unambiguously expressing their desire for food that is more concerned with health and respect for the planet's resources, as well as animal welfare. Moreover, Europe as a whole is very sensitive to environmental issues and has made them a spearhead of its development actions. Cop 21, Paris Agreements, this localization of the political commitment to the ecological transition owes nothing to chance. Economically and sociologically, the European market has nothing to envy the North American or Israeli markets.

Are we then simply too conservative? Certainly, Europe is a fragmentation of terroirs, all committed to offering exceptional products while playing a role of conservator of foods and tastes. Yet there is no indication that alternative proteins should take the place of meat or dairy products, which are rightly considered the best of Europe. On the contrary, the idea of a food mix has gained ground and is now imposed on all those who think, invent, and propose in the food sector.

In the end, is it a matter of questioning the quality of alternative proteins and the products they make? Here again, there is no room for doubt. It has been proven that Precision Fermentation, for example, contributes to providing pharmaceutical products (insulin) and food products (milk and dairy products) of very high nutritional or organoleptic quality. The problem is not to be tackled in these terms.

So, how can we make a measured but exploitable diagnosis that would allow Europe to play its role in this new and incredibly promising market?

What emerges from the study of the drivers of the alternative protein market, which are the USA, India, and Israel, is that due to the structural diversity of these countries, each has developed, as we have just seen, its alternative technologies for different motives. Rightly or wrongly considered as special cases, these reasons have the advantage of being recognized and proven by national actors in these markets. In a word, the United States attributes its leadership to what it sees as the natural right of the American people and economy to exercise hegemony. India, on the other hand, sees it as an expression of a vital need of its population. For Israel, it is a matter of existential security.

If European companies want to enter the game, they must in turn — and this is the lesson of the advance of the three driving countries — define a reason for the development of alternative proteins that

is specific to the EU and that is part of a logic of success. This could be the demand for taste and gastronomic culture or a more efficient way to accompany the ecological transition. Whatever the reason, it is up to the market players and the public or private funding bodies to define it. There is every reason to believe that the industrial justification phase, which consists of clearly and distinctly formulating the reason why the alternative protein must be present on the European market, is indispensable. It corresponds to the broad vision that, in another industrial context, allowed Europe to come together around the Airbus project, for example. The time has come, in the field of smart proteins, to create champions on a European scale.

This vision is all the more necessary as we cannot ignore the encouraging signals that indicate a willingness on the part of European start-ups to take a place in the market. Ynsect, Gourmey, Mosa Meat, Bon Vivant, among others, are beginning to make a name for themselves. The underlying economic logic is one of domination. Nature abhors a vacuum, and if European entrepreneurs and politicians remain too timid in the alternative protein sector, there is no doubt that initiatives from other countries will result in their products being sold in Europe.

WHO INVESTS?

What justifies capitalization in the sector of alternative proteins and milk proteins in particular, is the meeting between an available technology and the power of transformation of the production structures that it implies. A transformation that is in line with sustainable ecological change.

According to Sharyn Murray, senior Investor Engagement specialist at GFI, "The investment community is beginning to see the enormous potential of alternative proteins to transform our food system, as well as the strong ability to meet their return targets. As more and more investors recognize that climate risk is also an investment risk (stranded assets), alternative proteins offer a scalable solution that moves the Global Community closer to a safer, carbon-neutral food system. It is impossible to manage climate risk without addressing food, and agriculture and alternative proteins offer us a tool to do so."

Caroline Bushnell, GFI vice president of Corporate Engagement, says, "Given the magnitude of emissions reductions that would occur with a shift to alternative proteins, this is a critical time to invest in the technologies and innovations that can move our food system to net zero, and quickly. Increased investment in sustainable alternative proteins will allow companies to fund fundamental R&D, increase production, and reduce costs to effectively compete with conventionally produced animal proteins and, ultimately, put alternative proteins on more and more plates."

In this massive market, what about the financial appeal of Precision Fermentation in particular?

Fermentation companies dedicated to alternative proteins have secured $1.7 billion in investment in 2021, nearly three times the $600 million raised in 2020. Fermentation companies have raised $2.8 billion in capital since the first investment GFI tracked in the industry in 2013. Even more surprising: 60% of that amount has been raised in 2021 alone. This includes Nature's Fynd's $350 million Series C, Perfect Day's $350 million Series D, Motif Foodworks' $226 million Series B and The EVERY Company's $175 million Series C. In 2021, the sector's investor base increased 43% from the previous year, bringing the total number of unique investors to 434.1

The question of investment is therefore central and is divided into two components: public and private financing.

PUBLIC FUNDING

WHY DO WE NEED PUBLIC FUNDING FOR FERMENTATION RESEARCH?

The world's leading governments are growing their economies by investing in cutting-edge research. There is no doubt that public research pays off. For example, the technologies used in our cell phones (two-way radios, microprocessors, the Internet, miniaturized sensors, touch screens) were all developed in part through public research funding.
Governments around the world already spend billions of dollars on agricultural research for innovation, tens of billions on renewable energy, and even more on health. Allocating just a fraction of that amount to alternative protein research would have significant benefits in all these areas and more. Benefits include long-term job creation, protection against infectious diseases, and reduction of agriculture's negative impact on the climate.

BENEFITS OF PUBLIC FUNDING

ECONOMIC GROWTH

Public funding of alternative protein research could prime the pump to dramatically improve food system productivity and economic growth. This growth will translate into new opportunities for farmers and more skilled jobs, including engineers, biologists, and food scientists. Government-funded research would benefit public programs by increasing tax revenues or reducing tax rates. Former USA Secretary of Agriculture under the Obama and Biden administrations, Tom Vilsack, recognized the economic benefit of investing in public research, "Studies have shown that every dollar invested in agricultural research creates $20 in economic activity."[1]

[1] GFI.

INVESTMENTS INCREASINGLY FOCUSED ON IMPACT

"We have had an internal nomenclature for a few years now with three categories: ESG integration (Environmental, Social and Governance) in all asset classes for which this is possible, then the «focus» category, with a more important ESG dimension, such as the implementation of ESG filters or measures like carbon intensity, etc. The third category is specifically about impact and includes all sustainable themes, credit bond funds that integrate objectives related to sustainable development into their management, and funds that focus on impact. The third category is more specifically about impact and includes all sustainable themes, credit bond funds that integrate sustainable development objectives into their management and impact funds oriented towards the Sustainable Development Goals.
As far as we are concerned, an impact fund is therefore a fund that has a sustainability objective in addition to its risk/return objectives."

Nicolas Bénéton
Senior client portfolio manager
at **ROBECO**

"We are facing a tsunami that will turn everything upside down! At Tikehau Capital, we are convinced that within ten years, no one will invest in a purely financial logic without considering the extra-financial consequences. Responsible investment will become the norm. This is already the case for the largest assets, the younger generations, and our clients in general.
Our ambition is therefore to quickly standardize the notion of impact in all our management activities."

Raphaël Thuin, Director of
Capital Markets Strategies at
TIKEHAU CAPITAL

"This year, we conducted a survey of a panel of institutional and private investors, which clearly shows the interest in this type of strategy: 60% of the investors surveyed want to increase the proportion of their investments devoted to it. Institutional investors have led the way, but awareness is now widespread, with the Covid-19 pandemic being a catalyst. All players want to finance the economy in this way."

Thibault Amand, Director of
Sales for France at **VONTOBEL**

FOOD SAFETY AND SECURITY

Public funding of alternative protein research will also help diversify the food supply by ensuring both variety and food safety. For example, alternative proteins do not introduce zoonotic diseases (diseases of animal origin) because they do not require live animals. By protecting the food supply from extreme weather conditions, disease outbreaks, and the emergence of diseases and parasites, alternative proteins offer greater security, reliability, and flexibility.

PRIVATE FINANCING

With greater flexibility and often considerable volume, private investment is a good indicator of market vitality. To get an idea of this, nothing beats a recent review of private capital flows into food biotechnology. Here is a non-exhaustive list of venture investments by operation in 2020 and 2021 in the non-animal milk protein production sector alone, produced by Precision Fermentation.

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EXAMPLES OF PRIVATE INVESTMENTS IN PRECISION FERMENTATION MILK PROTEIN

PERFECT DAY *United States*

Fermentation Dairy
$750 million
Latest: September 2021 ($350M)

The $350 million Series D funding round was led by Temasek and CPP Investments, including participation from Horizons Ventures and Bob Iger, as well as SK, Inc. The round brings Perfect Day's total funding up to $750 million.

REMILK *Israel*

Fermentation Dairy
$120 million
January 2022

The Series B funding round of $120 million was led by Hanaco Ventures and included Rage Capital, CPT Capital, Precision Capital, Atento Capital, Tal Ventures, Chartered Group, Israeli dairy giant Tnuva and OurCrowd.

FORMO *Germany*

Fermentation Dairy
$50 million
Latest: September 2021 ($42M)

The last Series A funding round was led by EQT Ventures, with Elevat3 Capital and Lowercarbon Capital. The round brings Formo's total funding up to $50 million.

IMAGINDAIRY *Israel*

Fermentation Dairy
$28 million
Latest: May 2022 ($15M)

The $15 million funding round was led by Target Global and joined by Strauss Group, Emerald Technology Ventures, Green Circle Foodtech Ventures, Collaborative Fund, New Climate Ventures, and FoodSparks. The round brings Imagindairy's total funding up to $28 million.

NEW CULTURE *United States*

Fermentation Dairy
$25 million
November 2021

Led by tech investor Ahren Innovation Capital and alternative protein investor CPT Capital. Other investors include the American food ingredients giant's ADM Ventures, Dr. Oetker's-backed Be8 Ventures, and S2G Ventures, Marinya Capital and Future Ventures, run by Jurvetson and partner Maryanna Saenko. Earlier backers also participated in the financing, including SOSV's IndieBio program,

Bee Partners, Mayfield, Bluestein Ventures, and Kraft Heinz's venture capital arm Evolv.

BETTER DAIRY *United Kingdom*

Fermentation Dairy
$24 million
Latest: February 2022 ($22M)

The latest $22 million series A funding round was led by RedAlpine and Vorwerk, and joined by Manta Ray, Acequia Capital and Happiness Capital and Stray Dog Capital. The round brings Better Diary's total funding up to $24 million.

HELAINA *United States*

Fermentation Milk
$20 million
November 2021

Co-led by early-stage tech investors Spark Capital and Siam Capital. Participating investors included Primary Venture Partners and Plum Alley Investments, as well as American celebrities like Tom Williams, Hannah Bronfman, Gabrielle Union, and Matt Rutler among others.

STOCKELD DREAMERY *Sweden*

Fermentation Dairy
$20 million
September 2021

The round was led by existing investors Astanor Ventures and Northzone, and saw participation from new investors like Gullspång, Re:food, Eurazeo, Norrsken VC, Edastra, Inventure and Trellis Road.

CHANGE FOOD *United States*

$15.3 million
Latest: February 2022 ($12M)

The $12 million round was led by Route 66 Ventures, with participation from Upfield, Blue Horizon, Sigma, British soccer player Chris Smalling, and more. Additionally, Change Foods has signed strategic collaboration agreements with both Upfield and Sigma. The round brings Change Food's total funding up to $15.3 million.

STANDING OVATION *France*

Fermentation Dairy
$12 million
September 2022

The Series A funding round was led by Astanor Ventures with the participation of Peakbridge, Seventure Partners, Bid Idea Ventures and Good Startup.

04 — The market for alternative milk proteins: an international, financial and political race

REGULATION AND THE NEED FOR A COHERENT POLICY

Since the volume, nature and origin of the capital flowing into food biotechnology and Precision Fermentation are clearly observable and quantifiable, what matters now for all countries is clear, strong, and flexible regulation.

Above all, we can expect politicians, when faced with decisions to be made in today's rapidly changing food sector, is to resist ideology. More than ever, government and legislative bodies must base their actions on factual data. We still hear too often, at all levels of public discourse, a confusion between GMOs and 'from GMOs'. It is important to understand that the production of non-animal milk protein provides the consumer with a non-GMO food. It is equally important to know that the microorganism modified to enter the Precision Fermentation process leaves no trace in the finished product. Working to clarify this distinction is not only a matter of intellectual honesty, it also involves knowing what you want.

Faced with the challenges of food self-sufficiency and climate urgency that are far beyond what we have ever known, it is also up to the political class to take responsibility. It is a question of vision. But it is also a question of facts in which objective elements count more than irrational blockages. To illustrate a scientific advance concerning the absolutely positive use of a GMO product in our modern societies, one example will suffice: it would not occur to anyone to question the contribution of insulin in the treatment of diabetes. Let us remember that before its production by fermentation, insulin of animal origin (bovine and porcine) was used, the availability of which is no longer assured in many countries. Insulin obtained by Precision Fermentation does not face a resource problem and therefore meets a real need for pharmaceutical self-

sufficiency. This substance, once again, derived from GMOs and directly injected into the patient's body, contributes to his health and well-being. And this is an unambiguous development. On what argument could one therefore rely on to consider as unfit for human consumption what is attested as essential to public health?

The only opinion that can change reality is the one that has the force of law. It is the power to decide what our world should look like. It is an essential element of politicians who are educated by the results of scientific research. In these matters, only the facts established by impartial study and demonstrable results if we are to address the challenges of global food and climate emergency. It is up to the regulatory authorities to understand the necessity of protein production through innovative biotechnologies.
Firstly, to defend its merits to consumers, who are also its beneficiaries; and secondly, to support companies that have decided to find their place in a highly competitive global market. Finally, it is the responsibility of the legal authorities to put in place the regulations necessary for the development of the industry and its supervision.
More than ever, and more than anywhere else, the requirements of traceability and quality must be satisfied by a clear framework that allows all parties to commit themselves fully.

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DYNAMICS OF THE PRECISION FERMENTATION MARKET

DETERMINING FACTORS

• Significant investments and funding in the field of Precision Fermentation.
• Growing adoption of vegan and vegetarian lifestyles.
• Production of precision fermented ingredients with a smaller carbon footprint.

CONSTRAINTS

• Initially, higher manufacturing costs associated with the production of ingredients using Precision Fermentation.

OPPORTUNITIES

• Development of new protein production systems.
• Reduced production and supply chain costs.
• Competitive cost of products compared to animal-based proteins and other alternative proteins.

CHALLENGES

• Commercialization and scale-up of production.
• Customer acceptance of precision fermented products.

Afterword

The environment-related topics have never been so prominent. The distressing speech is often the same, forecasting increasingly worrying futures. This subject makes us react and concerns us all, that is why we must act.

While the challenges we face in this green transition are significant, so are the technological advances we make every day. This is the purpose of our mission, to find and develop sustainable solutions for the planet community.

Now that we are aware of what is at stake and that each of us can help improve the situation, we can act and work together for the greater good. Whether we are a consumer, a researcher, an entrepreneur, an industrial, a politician, a banker, or an international civil servant, we all have a role to play.

At Bon Vivant we are optimistic and believe that we are at a turning point. We hope that this white paper has contributed to the understanding of this complex and exciting subject, which is central to the fight against global warming.

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Bon Vivant