WELL_NZ: Alternative Protein 2022 – establishing a fact-base

A REFERENCE DOCUMENT FROM TE PUNA WHAKAARONUI:
NEW ZEALAND'S INDEPENDENT FOOD AND FIBRE SECTOR THINK TANK

SUMMARY

Te Puna Whakaaronui

Te Puna Whakaaronui is New Zealand's first food and fibre sector think tank and was established as a key action under the *Fit for a Better World* Acceleration Roadmap, fulfilling the Primary Sector Council's recommendations for pan-sector thought leadership. It will support New Zealand's food and fibre sector transformation over the next ten years. Te Puna Whakaaronui's role is to help lead, co-ordinate and implement transformation; through partnering with Māori and sector participants to provide thought leadership, strategic insights and advice.

The think tank has a voice independent of the Ministry for Primary Industries, its view does not represent Government policy.

The full *WELL_NZ: Alternative Protein 2022* report and this summary report are available at: **tpw.org.nz**

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Te Puna Whakaaronui

Contents

Foreword

Predictions of 'meat without an animal' have been made by scientists and philosophers for decades, finally becoming a reality in 2013 when academic Mark Post unveiled the '€300,000' hamburger. Interest has continued to grow and a proliferation of headlines now claim that either alternative-proteins (alt-proteins) are on the verge of disrupting everything we know about food within five to ten years, or that alt-protein proponents are, at best, optimists.

Each year there seem to be more reports, news stories, analyses and rebuttals on the topic of 'meat without an animal' – yet no consensus. Consequently, ground-truthing how plausibly, and how quickly, alt-proteins will become a credibly large part of the food system is difficult. The current conversation about disruption traverses more than meat. Advances in recombinant protein production, or 'precision fermentation', have the potential to produce actual dairy proteins, not simply mimic them, raising questions of their impact on the future of global dairy trade.

Te Puna Whakaaronui has engaged with a broad range of contributors to the national discussion on the future of alternative protein. There is certainly a diversity of genuinely held viewpoints. There is consensus that any significant impact on conventional farming has the potential to create social and economic pain for New Zealand. Sceptics and critics see major technological and logistical production challenges. Advocates see a pathway to reduce environmental impacts, improve animal welfare and increase food sovereignty. Earnest belief does not, however, help move New Zealand's national conversation along.

Understanding the development of alt-proteins, and the extent to which they might (or do) compete with conventionally produced animal protein is key. Are they a risk, or an opportunity? How serious is the potential for disruption? The first step towards that understanding is for more people to be informed about how plausible these technologies are. If they are plausible, then what is the potential impact of alt-proteins on New Zealand's meat and dairy sector?

These are uncomfortable questions, but ones we cannot ignore. *Alternative Protein 2022* cannot, and does not predict if, when, or by how much, alt-proteins will disrupt conventional meat and dairy. But it does demonstrate that disruption is plausible. Managing global technological development, and the speed that it will impact our conventional food production sectors, is beyond New Zealand's control. All we can do is manage how well prepared we are. The decisions we make today, and how we prepare our sectors, will determine whether our economy thrives or stumbles through the next fifty years. New Zealand simply cannot risk taking a reactive approach and waiting until disruption is a certainty.

There also needs to be an understanding of the technology and trends that have the ***potential*** to precipitate disruption to our meat and dairy sectors. Understanding competitive production methods of all kinds will help inform proactive preparation to safeguard, not only our economy, but our people and our communities ***if*** significant disruption does occur. The sector is cognisant of these technologies and government is beginning to develop a view. However, the rate of global change means we need to do more – and faster – if we are going to fully embed resilience and embrace the opportunities that change creates.

Ultimately, Te Puna Whakaaronui's view is that disruption, if it occurs, won't be total. It is not a question of absolutes, of 'how many cows'. It isn't a competition between production methods for the lower environmental footprint. There is a great deal of work going into methane mitigation, on-farm changes and other solutions that will shift this equation. Instead, this is a question of how New Zealand stakes out and maintains a value proposition alongside the development of alt-proteins, should alt-proteins prove to be a significant challenge to conventional food production. Improving primary sector resilience to global shocks and significant change is critical.

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Section 1: Context

Why an alt-protein report?

New Zealand is one of the world's major exporters of protein (in the form of meat and dairy) and these products play a significant role in the New Zealand economy, not only in terms of direct exports, but also in downstream industries and in the lives and livelihoods of rural communities. Understanding potential impacts on future demand for New Zealand's meat and dairy is critically important. The global population of 8 billion is expected to increase by 1.5-2 billion people in the next twenty to thirty years. More people inevitably mean an increased global demand for protein.

Despite growing demand, the food system sits against a complex backdrop of geopolitics, inequality of access to food, environmental degradation and increasingly severe climate change impacts. Inevitably, the pressure food production methods place on resources, the environment and supply chains are under scrutiny. In order to meet both growing demand and address increasing global constraints, alternative food sources and production methods are being developed at an accelerating rate. For New Zealand, understanding the global context of alt-proteins – what they are, how quickly they are developing, and what role they could play in the global food chain – is key to understanding future demand for New Zealand's meat and dairy.

Alt-proteins present the potential for major disruption of the current food system by fundamentally shifting both how, and where food is produced. However, general understanding and awareness of alt-proteins varies considerably. Publicly available information is a mix of academic research papers, investment headlines and industry reports, often attempting to forecast the next ten to twenty years of economic impact. There is not, however, a consensus view, which makes it difficult to determine fact from fiction. How plausible are the claims of 'milk without cows' in ten years? Are the technical challenges of making lab-based meat really insurmountable? Are these 'Frankenstein foods', unpalatable to the consumer or just another ingredient?

The full *WELL_NZ: Alternative Protein 2022 – establishing a fact-base* report, aims to bridge the gap between dense technical literature, hyperbolic headlines and the global narrative. Importantly, it ground-truths the potential impact of alt-protein on conventional production in a New Zealand context. It doesn't seek to argue for, or against, the development of alt-proteins, nor does it seek to critique conventional farming, or argue that one is better (or worse) than the other. Most importantly it doesn't seek to predict the future. Instead, this report has two goals:

- to help navigate the mass of information towards understanding how plausible alt-proteins are as a disruptor to New Zealand's export profile; and
- to explore the impact of alt-proteins replacing conventional dairy and meat to varying degrees.

Te Puna Whakaaronui intends that this report will ground-truth publicly available information and form the basis for discussion within the primary industry sector alongside iwi, academia and government. It is important for the sector, and the wider economy, to develop a deeper understanding of alt-protein impacts and opportunities in a unique New Zealand context.

The report approach

The full *WELL_NZ: Alternative Protein 2022 – establishing a fact-base* report contains detail and full source referencing. It is available on-line at: tpw.org.nz. Sections two and three establish an information base from a review of media reports, industry press releases, websites, academic literature and publications from industry, government and multi-lateral organisations. The review considers current production costs, challenges and focus areas of scientific and consumer research to form a picture of the plausibility of disruption to conventional meat and dairy production. This report identifies where key information is unavailable.

Then, in section four of the report, we consider illustrative (not predictive) disruption scenarios. To do this, we take existing scenarios developed by global industry and academics, and outline disruption to the global meat and dairy trade. Using these scenarios, we then model the potential impact on New Zealand using the Organisation for Economic Co-operation and Development (OECD) global agricultural model AGLINK-COSIMO. Two scenarios are modelled:

- a simulated economic shock to the dairy sector in 2030 through a reduction in global demand for conventionally produced Skim Milk Powder (SMP) and Whole Milk Powder (WMP); and,
- a simulated economic shock to the red meat sector in 2030 through a reduction in global demand for conventionally produced beef.

Finally, in section five of the report, we bring the compilation of publicly available information together with the modelling; we explore the scenarios, discuss their plausibility and identify what would need to happen for the scenarios to occur.

What are alt proteins?

For most people alternative proteins – or alt-proteins – have become fairly common ideas, bringing to mind oat milk or Impossible Burgers. These products regularly feature in institutional reports as well as media coverage of food and fibre sector investment, innovation and disruption.

Alt-proteins present the potential for major disruption of the current food system by fundamentally shifting both how, and where food is produced.

Discussions include topics as broad as:

- new product, business launches and acquisitions;
- geopolitical disruption and supply chain constraints;
- technological advances;
- shifting and emerging consumer preferences;
- animal welfare and climate change; and,
- the environmental impacts of food.

Yet, despite the explosion of documents, it is often unclear where the boundary sits between what is, and what isn't, an alt-protein. Further confusion results from the emergent nature of the terminology, it is still being developed in response to consumer preferences and regulation. For example, do people prefer the use of cultured or lab-based meat, and, is plant-based meat, 'meat'? Adding to the complexity, alt-proteins often involve new technologies, new applications of existing technologies and emerging areas of research.

There are, however, some common elements of a definition: alt-protein foods are a high-protein product, that would traditionally have been produced via an animal, but that has been made without using an animal and/or farming an animal.

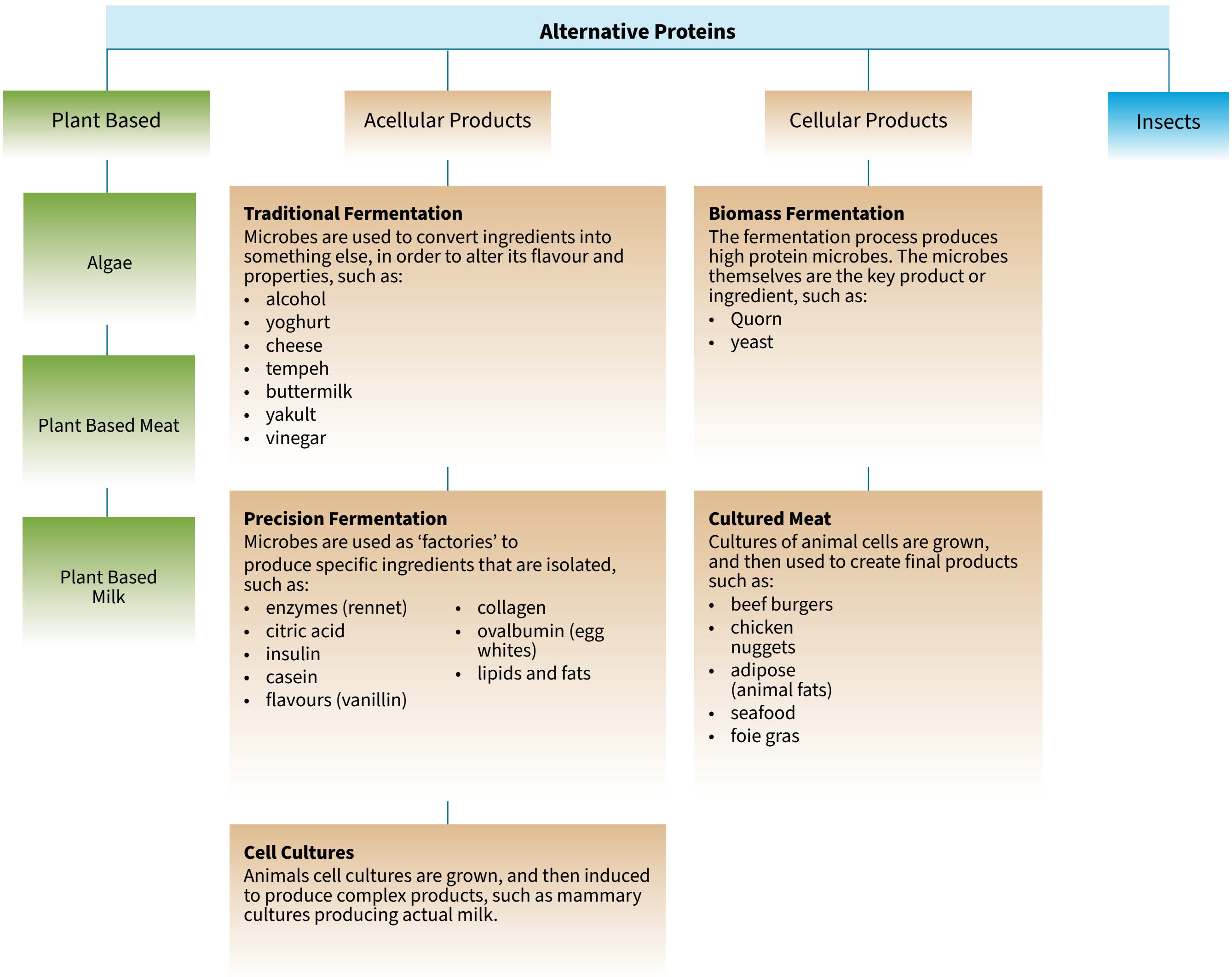
Alt-protein products can be segmented based on:

- the source (plants, insects, animals or micro-organisms);
- whether the source ends up being in the end product itself (for example chickpeas in chickpea flour); or
- the source produces something else but is not itself the product (for example yeast producing alcohol from sugar).

The diagram below sets out this basic segmentation but is not exhaustive.

This report focuses on the production of milk and meat alternatives, particularly: cultured meat, precision fermentation and meat analogues (plant-based products that have been blended with flavouring, fat and colour to look, feel and taste like meat from an animal). It does not focus on traditional fermentation (like alcohol production), biomass fermentation (such as *Quorn*™), or insects.

Figure 1: What can alt-proteins make?



Section 2: Meat

Conventional meat

Meat in the New Zealand economy

Conventionally farmed sheep and beef is an undeniably vital part of New Zealand's economy. It is not only our second largest export product, earning around NZ$10-11 billion annually, but it also contributes significantly to downstream industries and the communities they support. Around 92,000 jobs, or 4.7% of New Zealand's total employment, can be linked back to the red meat sector. It's fair to say that any major shocks to the red meat industry would have significant impacts on both the overall economy and the communities that the industry supports.

New Zealand's role in global meat markets

Although this report focuses on sheep and beef meat production in New Zealand, it is important to remember that sheep and beef meat is not produced in isolation; both the production of meat, and New Zealand exports, are embedded within a global context. Globally, much more meat is produced and consumed in the country of origin than is traded. In 2020 for example, the world produced an estimated 328 million tonnes of farmed animal meat, however, only 36.3 million tonnes of this were subsequently traded.

New Zealand accounts for only 1.5% of global sheep and beef meat production, but 8.1% of exports. We also have highly concentrated export markets, with nearly 60% of our sheep and beef exports going to the US and China. While the overall global volume of meat imports is currently growing at 6% per year, there are signs of slowing beef consumption in many markets; the Food and Agriculture Organization of the United Nations (FAO) projects a 5% drop in global per capita consumption of beef by 2030.

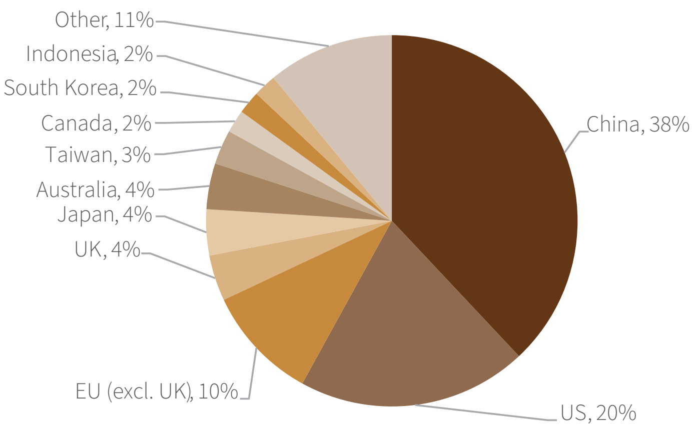
Conventional meat production costs

In order to compare cultured meat production with conventional meat production, we have focused on the NZ$ cost per kilogram of meat leaving the farm. This is because most of the analyses of cultured meat production costs focus on intermediate cultured meat product, rather than the cost of a final consumer product. The cost to produce a kilogram of meat leaving the farm is more evenly comparable than the cost to produce a kilogram of mince leaving a meat processing facility.

Production costs in New Zealand are commonly expressed in 'Stock Units', a means of assessing the relative feed demands of farmed animals. The Stock Unit is based on the annual feed needed for a 55kg ewe rearing a single lamb. A dairy cow is the equivalent of about seven ewes, so is counted as seven Stock Units.

Conventionally farmed sheep and beef is an undeniably vital part of New Zealand's economy.

Figure 2: Destination markets for New Zealand Exports of Meat and Wool (Year to 30 June 2021)



In addition New Zealand has multiple farm types (Classes 1-8) each with a slightly different purpose, from rearing through to 'finishing' farms. For the purpose of this report, it is sufficient to look at a range of reasonable production costs across farm types using:

- average production cost per Stock Unit;
- average meat produced per animal; and
- average Stock Units per animal.

This calculation method will compound averages, making the accuracy at the margins low and we therefore recommend future work to develop a more accurate measure. Our estimate puts the cost per kilogram of meat, excluding Class 8 farms (which tends to be an outlier), between NZ$1.30-3.80.

Plant-based meat

The current state of plant-based meat

Plant-based meat substitutes, in one form or another, have been around for centuries (e.g. tofu) and meat 'analogues' ('fake' meats) since at least 1896. However, the last thirty years have seen a far more concerted effort to develop plant-based products that mimic the mouthfeel, cooking behaviour and taste of meat.

Overall, investment in plant-based meat has demonstrated significant growth over the last few years, from a small base. Plant-based meat holds around 0.5% of the global meat market. In February 2022, the Good Food Institute estimated that total US investment in plant-based proteins (meat and dairy combined) at US$6.3 billion between 2010-22, with US$1.9 billion of that invested in 2021 alone. However, this compares to a global conventional meat industry estimated to be worth US$1.7 trillion. There are signs that conventionally farmed meat growth may have started to slow, with sales falling for the first time in recent years 2021, by 0.5%.

Production costs

Because there is an array of plant-based meat types and technologies in use, it is difficult to estimate production cost, and therefore an aggregate 'plant-based meat production cost' is meaningless. Where estimates are available, they place *Beyond Meat's* cost of production at US$4.50 per pound (NZ$15.80 per kg) in 2019 and US$3.50 per pound (NZ$12.30 per kg) in 2020.

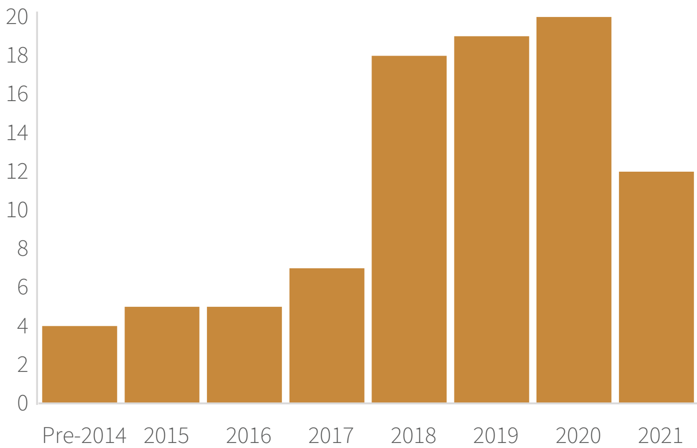
Cultured meat

What is it?

A type of cellular agriculture, cultured meat (also called lab-grown meat, cell-based meat, or cultivated meat) involves:

- collecting a small sample of cells from an animal, potentially leaving the animal alive and unharmed; and,
- growing the cells in bioreactors or 'cultivators' until they yield a large quantity of fat and muscle cells that can be combined and processed with other ingredients into food products.

Figure 3: Cultivated Meat Companies by Founding Year



Source: GFI Company Database

This process results in actual meat products. In some instances, the cells can also be grown on an edible scaffold, or 3D printed to produce structured products (e.g. chicken breast or steak).

Strong growth in cultured meat investment has seen capital investment increase exponentially from a low base. Cultured meat was initially being developed by mostly small, boutique, biotech firms and start-ups, there are now growing levels of investment from major food producers such as *Tyson Foods and Cargill*. These businesses are able to leverage significant capital, research and development, infrastructure and supply chains, as well as their global distribution networks and relationships.

Key challenges

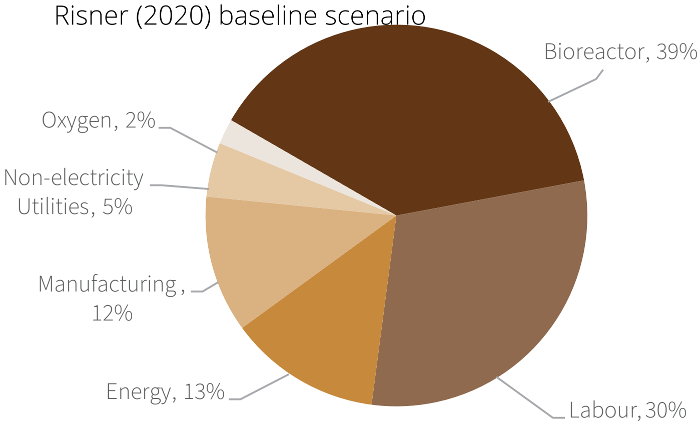
The three big questions, and constraints, for the viability of cultured meat as an industrially produced food source, are whether:

- it can be sold legally;
- people will buy it; and,
- it is economically viable.

Regulation

One of the key constraints on cultured meat is whether regulatory systems are equipped to consider it under their 'novel food' regimes, and whether they approve it to be sold for human consumption. Although many

Figure 4: Cultured Meat Production Costs
Risner (2020) baseline scenario



Source: https://acbmcostcalculator.ucdavis.edu/

jurisdictions have novel food regulations that would ordinarily cover new foods, the nature of cultured meat means that the application of existing regulation is not always clear cut. Particularly challenging is cultured meat's manufacturing process which borrows heavily from pharmaceutical manufacturing and may include genetic modification. Depending on the country and process, novel food approval can take anywhere from six months to two years – in the case of genetically modified foods this can be substantially longer, if at all.

As at June 2022, Singapore was the only country to have approved cultured meat for sale for human consumption, with the Netherlands approving it for human consumption on a limited basis.

Consumers

The second key question for commercial cultured meat is consumer behaviour – not only whether they will buy it and how much they will spend, but also whether they are willing to try it at all.

Recent consumer research tends to find that most people are willing to at least try cultured meat, ranging from 50-80%. This indicates that if cultured meat is appetising in terms of taste and texture, then consumer uptake may have few barriers. More importantly, most research finds that the more consumers are aware of cultured meat, the more they are willing to try it.

Technology

In addition to regulations and consumer intention, cultured meat also has a range of technical challenges it will need address to become economically viable. Considering the available information, the areas of the greatest potential gain tend to fall into three categories:

- cell lines and characteristics;
- culture media; and,
- bioreactors and process design.

The choice of specific cells or 'cell lines' to culture are crucial in developing a commercially viable product – it is the most challenging scientific constraint. Economically viable cultured meat requires the biological limits of cell growth density to be approached. Reducing costs means increasing cell growth rates and cell density in bioreactors, as well as improving cell metabolic efficiency.

While these advancements are all necessary, techno-economic analysis suggests they do not go far enough. By far the largest cost component for producing cultured meat in 2022 is the culture media; the solution that the cells are grown in. This accounts for 99% of current costs. The eight most common ingredients equate to around US$376 per litre, or US$7.5 million for a 20,000-litre bioreactor.

The third area of challenge is the capital cost of bioreactors or cultivators. These are key pieces of equipment for enabling the culture and growth of cultured meat. Current models are based on pharmaceutical designs which are smaller and more expensive than industrial food grade production of cultured meat needs. Further, in order to scale-up production there will need to be an increase, and price reduction, in bioreactor manufacturer to enable full commercial-scale production.

Production costs

The critical questions for conventional farmers are: what does cultivated meat cost to produce, and what is its trajectory? As Mark Post, the first person to produce cultured meat puts it, unfortunately there is "a lack of access to information that individual companies are not incentivised to share". In other words, there is limited robust, publicly available, verified information. We know broadly what the production costs are made up of, and that the largest current cost is the growth medium which generally makes up 99% of the cost.

The lack of access to detailed data on production costs and the rates of change of individual components, means a reliance one of two main sources of information:

- public announcements by cultured meat companies; and
- third party Technical Economic Analyses (TEAs) and predictions.

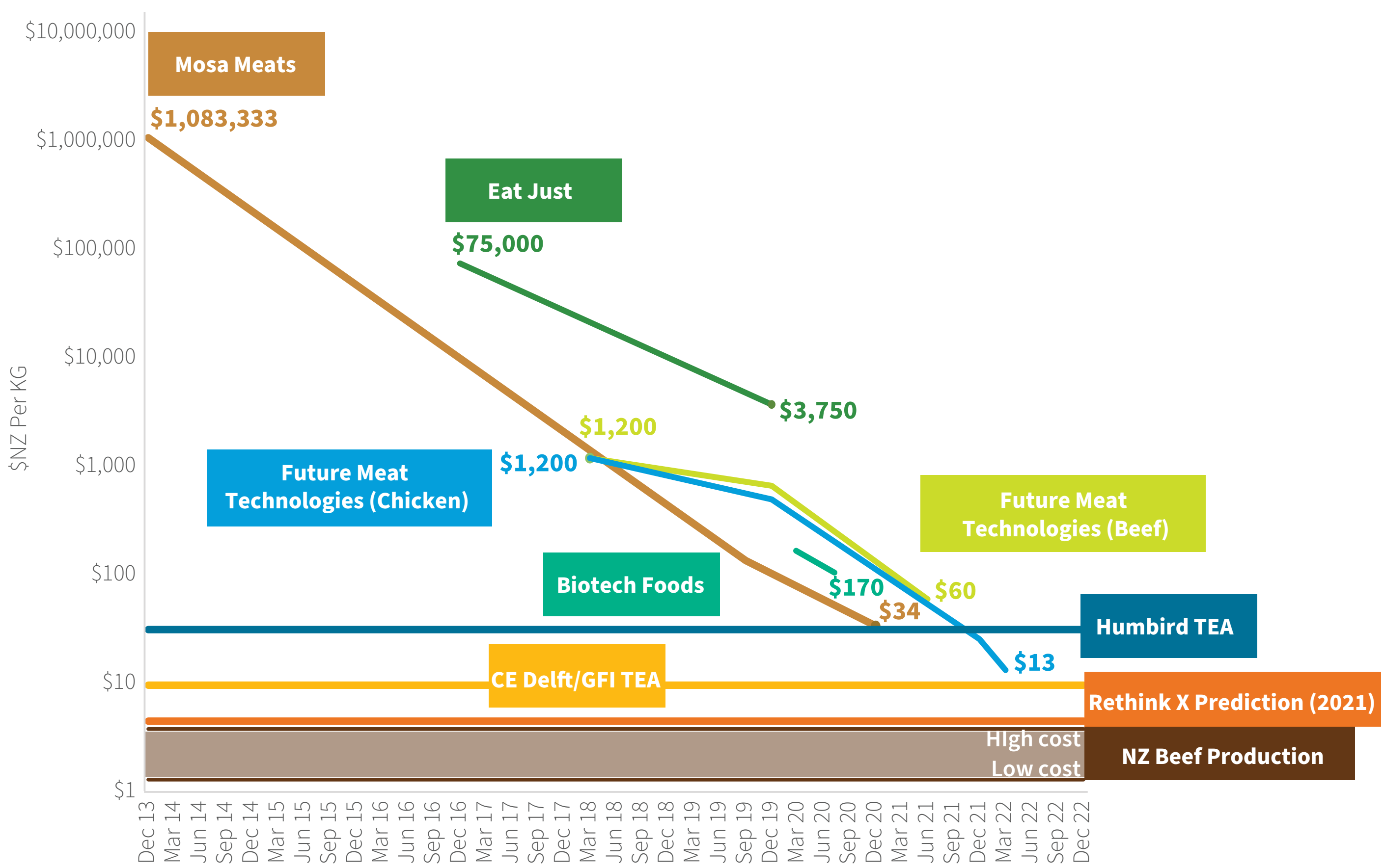
Recently there have been three major TEAs completed by: UC Davis, Dr. David Humbird and consulting firm CE Delft, on behalf of the Good Food Institute (GFI).

The graph below compares the 'plausible' estimates identified by the three TEAs against the production cost estimates of New Zealand meat, and then overlays publicly announced production costs. We can see that the reported production costs of some cultured meat firms have already fallen below the best plausible case of the Humbird TEA. But when the cultured meat product is blended with plant content, it rapidly approaches the scenario described by CE Delft/GFI.

Three aspects of the graph should be noted:

- a logarithmic scale on the y-axis is used, as otherwise the gap between NZ$1 million and NZ$10 million makes the graph unreadable. This effectively 'smooths' out significant drops in production costs. So, while the graph is distorted, the real graph is far more dramatic, not less;
- the mix of solutions that has led to the fall in costs is unknown. While publicly available information indicates that cheaper growth medium has been a key part of this, even reducing growth medium to $0 cost, is not sufficient to achieve the levels of cost reduction so far reported, which indicates that progress has been made against some of the other cultured meat production challenges; and,
- the production costs for conventional beef are based on current estimates. It is reasonable, given the trajectory of costs that we are seeing, as well as pressures from supply chains and regulations, that these will increase.

Figure 5: Cultured Meat Production Costs (Logarithmic Scale)



Section 3: Dairy

Conventional dairy

Dairy in New Zealand

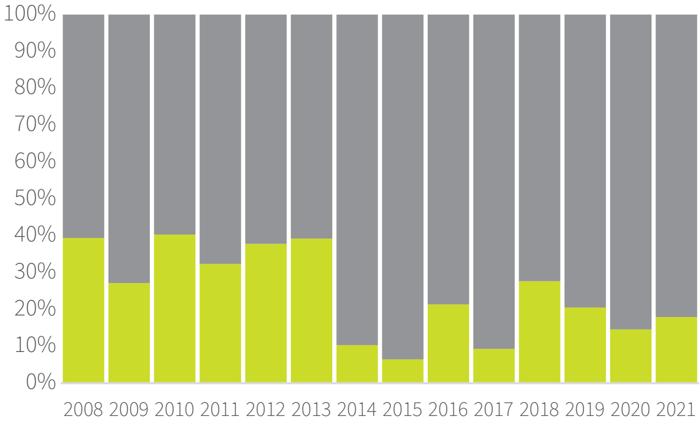
Like meat, dairy has long been one of the three pillars of New Zealand's economy, and remains our largest goods export. In 2021, 40% of New Zealand's export revenue was from dairy and it was worth NZ$19 billion to the economy. The overwhelming majority of this was through trade in whole milk powder (WMP). In 2020 dairy farmers and processors contributed over NZ$22 billion in economic activity. Dairy is directly responsible for over 50,000 jobs in New Zealand.

New Zealand distinguishes itself from comparator exporters (e.g. EU and US) by being primarily a pasture-based system, with some supplementary feeding. In contrast, other countries have more intensive farm systems, in the US dry-lot and free-stall systems are more common.

New Zealand dairy in the world

Only around 7-8% of global dairy production is traded across borders, with most dairy produced and consumed in the country of origin. Some of the largest dairy production and consumption markets, such as India, are not heavily integrated into the global dairy trade. In 2021, New Zealand was the world's fifth largest producer of milk overall, but the largest single-country exporter of milk products. We were responsible for 60% of the worlds whole milk powder (WMP) exports, and 12% of the worlds skimmed milk powder (SMP) exports. As with meat, our export profile is highly concentrated, China takes the largest proportion our dairy exports,

Figure 6: Proportion of Growth in Fluid Milk Retail Volume Due to Milk Alternatives



Source: Mintel

42% across categories. This context leads to New Zealand being a price-taker in global dairy markets and subject to the volatility of those markets.

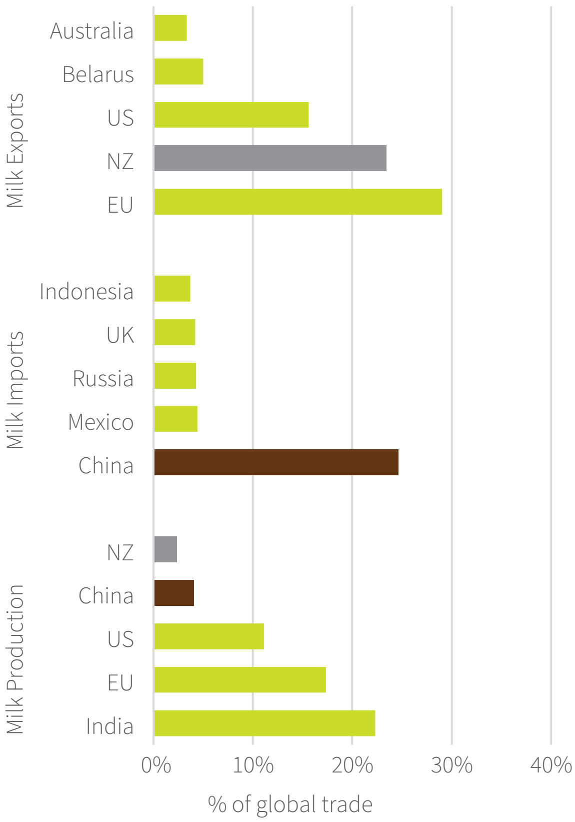
Production costs

New Zealand's dairy production systems are classified into five groups based around the amount of supplementary feed (in addition to pasture) that cows eat and the point in the dairy production cycle that supplementary feed is used. For analysis, these are commonly aggregated into low, medium, and high intensity systems with fairly well-established metrics for production costs. In 2019/20 these were:

- NZ$4.24-5.05 for low intensity systems;
- NZ$4.51-5.00 for medium intensity systems; and,

We are seeing increasing market segmentation along taste and dietary lines, meaning that many refrigerators may well contain more than one type of fluid milk.

Figure 7: Global Trade in Milk Products (2021)



Source: FAO

- NZ$4.40-5.26 for high intensity systems.

Plant-based milk

The current state

Plant-based milk currently accounts for around 15% of retail sales of fluid milk globally and has had steady growth over recent years. However, we are seeing increasing market segmentation along taste and dietary lines, meaning that many refrigerators may well contain more than one type of fluid milk. Valued at around US$2.5 billion, the US alternative milk market grew 20% based on retail sales in 2020.

Although the market showed some signs of slowing in 2021, it is generally predicted to continue with linear growth over the next few years. Interestingly, while sales in fluid milk alternatives have grown, traditional dairy sales appear to have been growing faster. This means that as global sales of fluid milk have increased, whether from population growth or more consumers buying fluid milk products, conventional dairy seems to have gained ground on alternatives.

Te Puna Whakaaronui does not view plant-based milk as a significant disruption risk to New Zealand's export profile. Plant-based milks tend to compete with fluid milk alternatives, rather than with whole milk powder, therefore the *WELL_NZ: Alternative Protein 2022 – establishing a fact-base* report does not focus on plant-based milks.

We acknowledge the potential for competition from fluid milk competitors experiencing disruption and diverting supplies into powder. But, on balance, plant-based milk products present a very different set of economic questions for New Zealand than precision fermentation does.

Production costs

There is limited information available on plant-based milk production costs due to the differing manufacturing techniques of the various types of plant-based milk.

Precision fermentation

What is it?

While precision fermentation is a relatively new term, it is a decades old process that allows the use of microbes (bacteria or fungi) to directly produce specific compounds called target products, without relying on an entire animal. In effect the microbes are small 'factories' producing a desirable molecule, such as casein or whey protein. These target products can then be extracted and combined with other ingredients to produce consumer products. Importantly, the process does not produce a target product that is 'similar' to the desired product, it produces the same desired product. A whey protein extracted from cow's milk, and a whey protein produced from precision fermentation, are virtually identical.

Milk, for example, contains hundreds of proteins, fats, sugars, vitamins and minerals. Precision fermentation could be used to produce these individually, and they could then be blended in the right proportions, to produce milk. The process could also leave out components – such as lactose. Some simple target products can be produced without genetically engineering the microbe. More complex target products (e.g. whey protein or casein) require microbes to be genetically modified.

Key challenges

Consumers

There is remarkably limited research into consumer perspectives of precision fermentation, but, where there is research, it tends to identify limited resistance. One study in 2021 looked at consumer interest in Brazil, Germany, India, the UK and US, finding that 78.8% of consumers indicated they probably, or definitely, would buy products made through precision fermentation. Many expect that cheese produced via precision fermentation will be better than current vegan cheese options.

One of the main barriers to consumer uptake is expected to be the role of genetic engineering in precision fermentation. Food grade, genetically modified, organisms are commonly distrusted and often poorly perceived by consumers. However, precision fermented products are already on supermarket shelves, and consumer reviews are generally favourable, indicating that this is not necessarily a hard barrier. Milk derivatives are in many products, from baked goods to potato chips, and the origin of the milk powder in these is rarely considered by consumers.

Most people will have encountered something with precision fermented ingredients in it, potentially without realising:

- synthetic rennet (Chymosin) is a cheesemaking enzyme that has been produced by precision fermentation since 1990 and now accounts for 80% of the world's supply of rennet;
- synthetic insulin, produced by precision fermentation since 1978, is virtually all now produced in this manner; and
- enzymes used in powders for washing machines and dishwashers.

Precision fermentation is also used to produce a wide variety of enzymes, flavourings, vitamins and other food additives.

One of the more established precision fermentation companies working on dairy replacements, US-based *Perfect Day*, produces whey protein as a business-to-business ingredient. Their business model involves partnering with a range of organisations to produce consumer products. Their first product, an ice-cream, was launched in 2020 and is now available in 5,000 stores across the US. By February 2022, they expanded their range to produce a wider range of dairy products: ice-cream (*Nicks; Graeter's; Brave Robot, Ice Age* in Hong Kong), cake box mixes (*Brave Robot*), cream-cheese (*Modern Kitchen; The Urgent Company*) and sports nutrition protein powders (*Natreve; California Performance Co.*).

Perfect Day has most recently teamed up with *Nestlé* to create a milk-like beverage from proteins identical to those from cows but with a smaller environmental footprint. It also partnered with *Starbucks* in late 2021 to run a trial in Seattle that used precision fermented milk. Reviews indicate that the final product is indistinguishable from conventional cow's milk in taste and function. In March 2022, *Perfect Day* partnered with *Betterland Foods* to produce a whole milk replacement.

Technology

As an established technology, precision fermentation is generally not waiting for major technical breakthroughs. Instead, it is currently limited by an historic focus on a small number of strains and target products. Expanding precision fermentation to produce food ingredient substitutes is mostly a matter of time, effort and funding to develop strains, reduce production costs and scale-up production.

Current technical constraints tend to be grouped around five areas:

- identifying and selecting the target product. Identifying which of the hundred or so proteins in milk are actually required to deliver the desired, nutritionally equivalent end product;
- selecting and developing the right strain of micro-organism. Historically production has focused on a small number of strains and target products, which we know well. New products require work to perfect the most efficient strains;
- developing the right feedstock. Currently, sugar is the preferred food of most strains used, but is also expensive and not produced in the quantities needed for major scaling-up. Alternative feedstocks (such as plant by-products from other food production processes) are being investigated but are not as efficient for the existing strains to metabolise;
- customising and scaling bio-processing. Each strain, and target product, needs to have its growth and extraction process perfected; and,
- formulating end products. While we know a lot about individual components, there is still room to improve our understanding of how we formulate end products and design standardised 'recipes'.

Regulation

New Zealand has more restrictive regulations around the importation and development of strains and use of genetically modified organisms than many other countries.

While the cultured meat regulation pathway is generally easier, precision fermentation faces two challenges under the existing novel food regulation:

- importation of micro-organisms to produce a target product; and
- approval to use the resulting target product as a food ingredient.

New Zealand's regulations apply to the process not the product. This results in a scenario whereby a genetically edited organism could be used to produce, for example, an edible fat or protein which is extracted and used as an ingredient, but, the final food product is classed as genetically modified even though no part of the original genetically modified organism is present.

Precision fermentation for food, however, doesn't face the same hurdles as pharmaceutical products. While industrial and food grade products need to maintain high levels of quality and safety, they do not face the same degree of regulatory requirements and oversight that pharmaceuticals do, in particular the need for expensive clinical trials. This is because novel food manufacturers are generally producing food ingredients as a substitute for a conventionally produced ingredient that has been consumed for a long period of time – they are simply changing the production process. As long as the manufacturing and purification process is safe, the approval process is generally not complex. In the US for example, once a product achieves the status of 'Generally Recognised as Safe' it doesn't require future novel food approval (e.g. precision fermented whey protein).

The regulatory regime for importation into New Zealand is complex, involving the New Zealand Customs Service, the Ministry for Primary Industries, the Environmental Protection Authority and requirements under several pieces of legislation. Three precision fermented products have been approved by Food Safety Australia and New Zealand (FSANZ):

- the soy-based 'heme' (Soy Leghemoglobin) has been approved as a food additive to the Impossible Burger;
- Lacto-N-neotetraose (LNnT), normally produced in human breast milk, has been approved as an additive to baby formula; and
- an additional human breast milk component, 2'-Fucosyllactose (2'FL) was approved in 2019 but has re-entered the approval process to enable the use of an alternate micro-organism.

Production costs

Precision fermentation production costs vary wildly depending on the target product. Precision fermentation is used to produce pharmaceuticals, food grade and industrial products. However, some industrial products sell for less than US$10 per kg, whereas some pharmaceutical products sell for billions of dollars per kg.

This disparity limits the comparability of these products as their cost structures are often very different. Compared to industrial and food products, pharmaceutical production has higher up-front costs in the form of clinical trials, the cell types used, the culture media, reactor and process design as well as quality control. In addition, industrial products are more commonly produced from fungi and bacteria, whereas pharmaceuticals often use cultivated mammalian cells, principally Chinese hamster ovary cells.

Digging into these production costs helps us better understand what needs to be reduced for precision fermented foods to reach price parity with conventionally produced foods. Production costs are heavily skewed towards capital and raw materials (the feedstock), but these vary depending on the target product. Substantial research and development time are factors not accounted for here. It can easily be in the order of eighteen months to two years, to develop a strain, optimise conditions and scale production. Although commonly used as a comparator, given its relatively well-known cost of production data, pharmaceutical production has significantly different cost stacks.

Section 4: Scenarios

Our approach

Building on publicly available information, the next stage of our report explores what disruption could look like for New Zealand, and what would need to happen for it to occur. The approach we have taken here is to simulate a specific economic shock, and then work backwards to investigate what events would need to occur in order for that scenario to arise. These scenarios can then be put through a quantitative model, deepening our understanding of the broader impacts. While not predictive, this approach still yields useful insights. While the specific way that scenarios might play out is complex, the important element for this report is whether a factor plausibly increases or decreases overall alt-protein uptake.

We explored low, moderate and high impact scenarios for two key products: beef, and milk powder (both whole and skim). Shocks were then modelled by drops in consumption of beef and milk powder in order to simulate alt-proteins increasing their global market share. This allowed us to then consider how these scenarios would play out for New Zealand.

Scenario modelling was carried out using the 2021 version of the OECD's global agricultural Aglink-COSIMO model. Aglink-COSIMO is a 'recursive-dynamic, partial equilibrium model'. This means that it considers individual sectors of the economy (such as dairy) and when changes are introduced (such as a fall in global demand for whole milk powder) it models the resulting adjustments to trading volumes and prices as the system settles into a new 'equilibrium' point, recursively feeding that back into the model on an annual basis.

Because the model considers the economy on a sector basis, factors such as land-use changes (e.g. dairy converting to beef or forest) are not included. There are also limitations on the size of the shock – the model may not be able to find an equilibrium point for very large, complex, simultaneous shocks. The process models a sudden shock in 2030. Disruptive technology tends to follow a pattern: a long slow tail as: products are developed, research and development is conducted, facilities and supply chains are built and a period of rapid accelerated growth ensues. This is also known as an 'S-curve'. This is not the only way that a scenario could play out but, considering actual investment acceleration, available price announcements and production scaling, this is a plausible growth trajectory.

The modelling 'results' are purely illustrative; they are not predictions of events.

New Zealand's existing industry structure is more resilient to shocks in the short term than most of our competitor countries.

Meat scenarios

Low impact (3% reduction in conventional beef consumption)

The baseline, or low impact scenario, is one where cultured meat has failed to enter the market in any substantial way but is beginning to show signs of progress. This could be caused by any of the major challenges failing to make at least moderate progress. For example, even with regulatory approval and consumer willingness to adopt, an inability to scale-up production facilities, significantly reduce costs, or demonstrate robust environmental credentials could lead to low uptake, or cultured meat being an expensive novelty.

Moderate impact (14% reduction in conventional beef consumption)

The two principal assumptions under this scenario are that there are sufficient approvals to sell cultured meat to account for 14% of global consumption, and, a significant number of consumers are willing to switch at least part of their diet to cultured meat-based products.

Other factors are fairly balanced. Consumers could be drawn to purchase, for example, either by lower priced cultured meat products, tempered by taste and texture issues, or if prices remain marginally higher, by strong environmental credentials. Similarly, environmental credentials of cultured meat (a topic that remains contested) could swing price pressures depending on whether cultured meat is able to robustly demonstrate that it is more sustainable than conventional meat. Challenges around capital costs, cell lines and a significant cost reduction of culture media would need to be overcome.

High impact (30% reduction in beef consumption)

This scenario has much less wiggle room and would require significant progress against all of the major challenges. There would need to be sufficient regulatory approval to account for 30% of global consumption and a significant number of consumers willing to switch at least part of their diet to cultured meat-based products. While this is necessary, it is not sufficient. To capture such a large section of the market cultured meat would need to:

- convincingly achieve price parity;
- demonstrate its safety, sustainability, nutritional and environmental credentials;
- see importers bring some cultured meat production onshore, and for domestic conventional meat production to be prioritised; and
- overcome all the major technical challenges.

Key findings

The main finding of the modelling exercise is that New Zealand's existing industry structure is more resilient to shocks in the short term than most of our competitor countries. Reducing global beef consumption by 14% for example, reduced our exports by only 7%. However, if the model was run over a longer time period we would expect to see a greater decline.

Limitations

As with all modelling, there were some limitations to the exercise. This means that while the insights are useful, they are not necessarily a reflection of reality:

- a high impact, 30% scenario was too large a shock to successfully model;
- the model does not differentiate between premium cuts and ground beef; and
- the model did not include countries taking steps to limit trade and protect domestic industries.

The moderate, 14% scenario resulted in a 27% reduction in global beef export prices, but as a reflection of New Zealand's product resilience, only a 7% reduction in beef export volumes. We also note that the interdependency of the beef and dairy industry means that a reduction in global beef consumption could also impact on dairy herds, and by extension, milk output.

Dairy scenarios

Low impact (0% disruption of global WMP and SMP consumption)

Under a low impact scenario, precision fermented milk powder replacements have failed to enter the market in any substantial way. This could result from a failure to gain regulatory approval or an unwillingness from consumers to eat products containing precision fermented ingredients. In addition, a failure to resolve any of the major challenges for key specific target products could also lead to this outcome. For example, even with regulatory approval and consumer willingness to adopt, an inability to adequately characterise and efficiently produce, the specific proteins necessary for milk would mean that while precision fermentation may disrupt other products, WMP and SMP remain safe from disruption.

Moderate impact (30% disruption of global WMP and SMP consumption)

A moderate impact scenario would require sufficient approvals for precision fermented dairy products to account for 30% of global consumption and a significant number of consumers willing to switch at least part of their diet to precision fermented products. But while this is necessary, it is not enough.

Most other factors would have to make significant ground in order for this moderate scenario to eventuate, and there are different pathways that they could follow. A small number of major milk importers, for example, would need to bring facilities on-line and start producing, or, a large number of small importers would need to bring an equivalent volume of production online.

As another example, consumer uptake could hinge on either precision fermented alternatives being cheaper than conventional products withstanding other downsides, or, prices remaining marginally higher but the alternatives demonstrating strong environmental credentials. Challenges around capital costs, as well as microbial strains that can efficiently produce target products, would also need to be overcome.

High impact (60% disruption of global WMP and SMP consumption

A high impact scenario eventuating would require overcoming most, if not all, of the challenges. Again, there would need to be a significant number of regulatory approvals and consumers would need to be willing to switch a large part of their diet to products including precision fermented ingredients. To capture such a large a section of the market, precision fermentation would also need to convincingly achieve price parity and would need to be able to demonstrate its safety, sustainability, and nutritional credentials.

In addition, either most major importers, or major food producers and many of the smaller ones, would need to switch to precision fermented ingredients for a substantial set of products. All technical challenges would need to be overcome: cheap feedstock options, multiple large-scale production facilities and well characterised strains and target products that can be efficiently cultured and extracted.

Key insights

As with the meat scenarios, the initial impact on New Zealand is limited as other, less efficient dairy sectors reduce milk production more than New Zealand, including the EU. Depending on our production system responsiveness, this would likely result in a decrease in WMP exports, but an increase in SMP and cheese exports. While modelling indicates that, in the short term, there would be some breathing room for New Zealand, this would still result in an overall fall of 12% of dairy export revenue under a 30% scenario, and a 25% fall in export revenue under a 60% scenario. If we had run these simulations over a longer period of time, we would expect to see a larger decline.

Limitations

There are of course several limitations to consider:

- the modelling did not constrain alternatives, such as cheese production. However, there are practical constraints on how much and how quickly the New Zealand dairy sector could pivot production. Currently we do not have good information on these constraints; and,
- the scenarios modelled a reduction in commodity milk powder, but there are producers working on precision fermented casein for cheese, meaning that cheese production could also be disrupted.

To test the model's sensitivity, a further scenario was run which did constrain other production streams. This resulted in much larger immediate impacts.

Section 5: Bringing it together

Overall view

One of the key purposes of this report is to better understand the plausibility of the disruption to New Zealand's key export products. A 2030 date was chosen to feed into the modelling as most reports and datasets have reasonable projections to this date. However, the date itself is not particularly significant. In order for alternative proteins to scale-up and take a 30% market share in what is now less than eight years, is highly unlikely. Supply chains are still being developed, production facilities are still being built at pilot-scale and then scaled-up, and strains are still being characterised. There is a lot to line up from an alt-protein perspective. But for the purposes of this report, the plausibility of that change happening is far more important regardless of whether it is 2030 or 2040.

What follows is Te Puna Whakaaronui's view on the plausibility of disruption, given the available evidence discussed in this report so far. We readily acknowledge that the evidence base is far from complete, and crucially, 'plausible' does not mean 'guaranteed'. The discussion around the plausibility of alt-proteins taking some market share does not mean that it will eventuate. We do not believe the specific scenarios would occur as set out, but a combination of the various elements discussed could cause disruption. It would, however, be prudent to take these technologies seriously, and for New Zealand to take a national view on alternative proteins – whether they are a threat or an opportunity. This needs to happen soon to avoid either missing out on any opportunity, or simultaneously, being too late to manage the threat.

What does this mean for meat?

On balance, Te Puna Whakaaronui's view is that there is a great deal of evidence supporting the plausibility of cultured meat and precision fermentation claiming some market share by 2030 or soon after. There are a great many challenges, and there are dozens of things that could fail to eventuate, but there is sufficient evidence of rapid progress and the prospect of cultured meat holding some market share within ten to fifteen years cannot be dismissed out of hand. That said, the pathway to disruption of 30% of the market is steep and would require everything to go right for cultured meat, and quickly. A 14% disruption to conventional protein production is more plausible as there are several pathways through which this could occur, in addition not every barrier would need to be completely removed.

There is a great deal of evidence supporting the plausibility of cultured meat and precision fermentation claiming some market share by 2030 or soon after.

To plausibly achieve market share there needs to be progress across the following key factors:

Novel food regulations: well-functioning novel food regulation is crucial to cultured meat being brought to market. Even with well-functioning regulation, sufficient applications need be approved. Singapore and the Netherlands are the first movers, but other countries (UK, US, China and the EU) are signalling their intentions.

Consumer willingness to try: surveys of consumer willingness to try cultured meat tend to indicate high acceptance. There are exceptions, with very mixed results from the US for example, but overall, consumers indicate that they are likely to at least try cultured meat. Consumers in the US, China, Japan, South Korea and Hong Kong, all major meat importers, indicate an openness to try.

Consumer willingness to buy: consumers must be willing to incorporate cultured meat into their diet on a regular basis, not just try it. There is little data on willingness to buy, what is available indicates that consumers would be willing to buy cultured meat if it was either:

- cheaper than conventionally produced meat; or
- at a higher price point with environmental sustainability, food safety, and/or animal welfare benefits.

Environmental and climate regulation: cultured meat will need to either demonstrate that it holds comparable or marginally worse environmental credentials to that of conventionally farmed meat and lower prices, or, it will need to demonstrate better environmental credentials. There is some progress here, but there does not yet appear to be a consensus view, often because production relies on parallel systems (such as energy) also having low emission credentials.

Geopolitics: in order to plausibly take global market share, it will not be sufficient for only one country, even a major meat importer like China, to develop cultured meat capability. Instead, it will take several countries to do so. But, for New Zealand, if a major meat importer like China were to develop that capability the impact would be significant. It is not immediately apparent where we would shift our current export volume to. China, the UK and the US are all signalling intentions to develop their own cultured meat capability.

Commercial pressures: realistically cultured meat would need to enter multiple market segments: budget, fast food and premium products; and likely extend into structured products (e.g. cuts of steak). With major producers like *Tyson Foods* and *Nestlé* already actively investing in cultured meat, and able to leverage their own distribution channels and relationships, then this becomes more plausible.

Price parity: culture media is the largest cost component and we are seeing significant progress in developing cheaper alternatives, as well as alternatives that do not rely on foetal bovine serum which is typically used in cultured meat production (for its nutrient density and growth factors). The price falls we are aware of at the cutting edge of production are large enough that they are unlikely to be due to reductions in growth media alone.

Technical barriers: these are the hardest to assess for plausibility as much of the information is closely held by cultured meat producers and many of the issues are very technical and highly specific. It is not yet clear that there has been sufficient progress in:

- improving genetic stability;
- optimising media consumption;
- developing immortal cell lines;
- increasing cell division rates; and,
- increasing the cell density (or yield per batch).

However, given the current rate at which cultured meat producers claim to be addressing key constraints, while it is unclear exactly what the time horizon will be, ten to fifteen years to achieve market share is not unreasonable.

Scaling of facilities: scaling-up cultured meat production facilities relies on sourcing expensive equipment that is often in limited quantities, and that often needs to be tailored to meet the needs of specific cell lines and production processes. Equipment also needs to be developed that is food grade rather than pharmaceutical grade. There is also a self-reinforcing element in that the greater the demand for equipment, the more equipment will be produced, and the lower the costs will become. Access to capital to fund this growth does not appear to be a constraint at the moment.

Availability of operating inputs: aside from capital, the two biggest input costs are labour and culture media. Skilled labour, particularly with the capability to scale and run these technologies, continues to be a significant constraint and requires a great deal more trained people than currently available to support the industry to grow. The talent pipeline, however, is unlikely to face the same labour market constraints as other conventional production once talent development begins. Production facilities for cultured meat can be located inside cities and the skills required for various biological manufacturing processes are widely available in the food manufacturing and pharmaceutical industries.

In terms of culture media, progress in replacing foetal bovine serum is being made, but there are also other ingredients in culture media that are costly, rare and that need to be food safe. For some there is simply a need to scale-up manufacturing in line with demand. For others there is a need to find alternatives or cheaper production methods. Evidence of promising research into all of these can be demonstrated, and interestingly, precision fermentation is being used to produce some ingredients (e.g. albumin). Once again, while there is insufficient evidence to be certain of when, and to what degree, culture media can be produced cheaply and in large quantities, it is plausible that these obstacles will be overcome.

What does this mean for dairy?

While culture meat production still faces significant technological boundaries, the constraints to deliver precision fermentation (at larger scale) are investment, time and effort. Technical challenges are being surmounted and novel, exciting science is underway, however, the bulk of the work to develop cost effective products is mostly incremental: developing and optimising strains, production, extraction and purification.

Given the available evidence, Te Puna Whakaaronui's view is that by 2030-35 it is plausible that there will be milk powders produced by precision fermentation on the market able to be sold in commodity ingredient quantities. They may not have reached 30% disruption, the timeframes to scale-up that much will be very tight. At this stage there are no precision fermentation businesses working explicitly on developing a milk powder substitute, producers are mostly focused on consumer products.

That said, the business model of most concern to New Zealand is that of *Perfect day*: business-to-business sale of key dairy proteins as a food product ingredient. *Perfect Day* is focused on whey protein and has multiple products on shelves already. The company has progressed from research to market with multiple products (including milk product trials at *Starbucks*) in less than eight years and is now working on scaling-up further.

Israeli company *Remilk* recently announced a scale-up of its facility to the equivalent of a 50,000-cow production operation. Just three years old, the company already produces cheese, yogurt and ice-cream for the consumer market. This makes a ten to fifteen-year time

horizon for significant global disruption of the traditional dairy industry plausible. Will disruption reach 30% or 60%, or will that take a bit longer? No-one knows, but it is not plausible to assume that it simply cannot, or will not, happen. Plant-based milks lack the nutrient density of cow's milk, and, as we have seen in recent years, will compete with each other for market share. However, precision fermented milk is simply a different way to produce cow's milk and may prove to be more disruptive to conventional global production.

Novel food regulations: a well-functioning novel food regulatory system is crucial to precision fermented dairy being brought to market. However, unlike cultured meat, there are many precision fermented products already on shelves. Where a product has already been consumed by people for a long period of time approval to produce a precision fermented equivalent should not prove difficult. Importation of cell strains and exporting target products could create the most friction.

Consumer willingness to try: survey evidence of consumer willingness to try precision fermented dairy products is limited, however, precision fermented products are already on shelves, which is a strong indicator of consumer behaviour. Over 80% of the world's rennet for example is precision fermented, and very few people are aware, or give it much thought. Consumers may distrust genetically modified food, however, most of the world's corn, soy, canola and sugar beets are genetically modified. Very few consumers tend to consider where cornstarch, corn syrup, oil or white granulated sugar in manufactured products came from.

Consumer willingness to buy: where survey evidence was available, it indicated that consumers were generally willing to buy products containing precision fermented ingredients, including current dairy consumers. For these consumers, vegan cheese options have not captured the taste and function of cheese. An alternative cheese made from the same proteins but produced in a different way, offers them the opportunity to reduce animal product intake but continue eating cheese of a similar function and taste,

Environmental and climate regulation: precision fermentation faces similar environmental challenges to cultured meat, and conventional dairy faces similar challenges to conventional meat production. Unsurprisingly, this means that for consumers, precision fermentation would need to produce cheaper products and have at least comparable environmental credentials, or better environmental credentials if it is marginally more expensive. To plausibly take a large market share, it would need to be both cheaper, and more environmentally friendly. However, that dynamic could shift in relation to business-to-business ingredient sales, where price sensitivity is generally more important.

Geopolitics: food security and geopolitics are likely to be key drivers of alt-protein development in many states. We expect this to play out through attempts to shorten supply chains, reduce consumption and support domestic producers. In relation to precision fermentation this is likely to be less of a risk for fresh milk which typically has shorter supply chains and is exported less often. Instead, it presents more of a risk for structured products like cheese and commodity ingredients such as milk powder and protein powder which tend to be shipped further and stored longer. The current dynamic of high dairy costs, while good for farmers, increases the incentive on states to develop products with lower price volatility, while highly variable prices create an incentive for products such as casein to be produced from alternate sources.

Commercial pressures: one of the bigger question marks over precision fermentation taking a reasonable market share, is whether it will be led by large firms that buy large quantities of commodity ingredients to manufacture consumer products en-masse, or smaller boutique firms that create direct-to-consumer products. The crucial difference is that consumer products will be much more subject to the whims of consumer preference, whereas commodity ingredients will primarily be driven by price.

Price parity: the primary cost drivers of precision fermentation, other than research and development, are the capital, the feedstock, the bioreactors and the sugar solution. Bioreactors are commonly produced for either industrial or pharmaceutical purposes, which makes them either large but not always suited to food grade production, or too small. Bioreactors also need to be tailored to the microbial strain and to the target product which will need to be extracted and processed.

Achieving price parity will rely on the cost of bioreactors coming down, which relies on demand for bioreactors going up. There is also research underway to develop alternative feed sources and make use of plant by-product streams from other processes, all of which contribute to cost reductions.

Technical barriers: precision fermentation has challenges around:

- identifying and selecting the target product;
- selecting and developing the right strain of micro-organism;
- developing the right feedstock;
- customising and scaling bio-processing and building recipes to formulate end products.

Each of these involve significant amounts of time, effort and funding to overcome, but none of them are plausibly insurmountable.

Scaling of facilities: key constraints to scaling production are:

- access to capital;
- funding scale-up given concurrent expenses and availability of sufficiently customised, food grade equipment.

We are seeing a significant amount of capital available for precision fermentation to enable scale-up and this amount is rapidly increasing, year-on-year. Further to this, as demand for expensive equipment increases, it is reasonable to assume that manufacturing will pivot to meet that demand, and costs will fall. The rate of scaling will naturally be a key constraint and reliant on multiple factors, however, we cannot assume that facilities will be unable to scale.

Availability of operating inputs: aside from capital, the two biggest input costs are labour and feedstocks. Unlike cultured meat, skilled labour is unlikely to pose a significant constraint, with recombinant and fermentation biology having been taught at universities for decades. The other factor, feedstock, is an active area of research. Where ingredients are in short supply, work is underway to find cheaper alternatives, and research is promising. It is also reasonable to assume that increased demand will lead to reductions in the price of key inputs, with increased manufacturing volume contributing to lower prices.

Next steps

This report sets out to ground-truth publicly available information about alternative proteins and explore how some modelled scenarios could play out for New Zealand. Te Puna Whakaaronui hopes that this platform of understanding will enable the sector to form a view on the plausibility of alternative proteins and to continue the conversation about competitive food production technologies and the implications for New Zealand.

Te Puna Whakaaronui believes that disruption to New Zealand's conventional meat and dairy industry, if it occurs, won't be total. The last two years have shown that alternative proteins offer us an 'and' opportunity, one where conventional and modern foods – together – meet increasingly complex consumer needs.

Limiting environmental impact is a focus for the primary industries sector, but the 'how many cows' conversation is obscuring a valuable discussion about opportunity. Work to mitigate on-farm environmental impacts and develop resilience in the face of climate change and other disruptions is essential to maintain domestic food supply and export capacity. But there are opportunities to develop niche modern foods, as well as wellbeing and beauty ingredients to grow our food and fibre sector for the benefit of all New Zealand.

How New Zealand stakes out and maintains its value proposition alongside the development of a global and domestic alternative protein industry is a conversation we must have with some urgency.

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