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Alternative Uses for Existing Crops: An Analysis of Potential Markets and Infrastructure and Supply Requirements in New Zealand

A Value Chain Assessment as part of Takahuri Whenua

by

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Executive Summary

Purpose

This report presents the findings of a value chain assessment undertaken as part of Takahuri Whenua. The objectives for the project were to investigate the potential markets for new crops, their infrastructure requirements, and to provide an indication of the supply requirements for an economic processing plant.

Three crops (products) were selected for consideration: Oats for milk; Peas (or beans) for protein extraction and; Chestnuts for flour production.

Potential Markets

Strong growth has been occurring in the key market segments – alternative proteins, plant based drinks and gluten free - in which these products sit. In addition, strong global growth was found in demand for the specific products of pea proteins and oat milk. The chestnut sector appears to be less dynamic.

Four main drivers that are strengthening the overall demand for plant-based products have been identified: consumer preferences (driven by health and lifestyle factors); environmental awareness; product research, development, and innovation and; governmental initiatives.

A review of market research reports, highlights that high compound annual growth rates are forecast for the products under consideration in many markets. Therefore, in terms of demand for the products, prospects appear bright both domestically and internationally.

Whilst overall demand for the products is strong, it should be noted that market growth for alternative meat products has currently stalled. High food price inflation (leading to a reluctance to pay a premium for alternative products) and increased questioning by consumers of the claimed health and environmental benefits of alternative meat products have been cited as possible reasons. There is disagreement as to the extent that the plateauing of demand represents a fundamental shift for the sector or is just a short term blip on an otherwise upward trajectory.

Challenges to the perceived environmental and health advantages for alternative protein products compared to livestock products have been made on the basis of their nutritional characteristics as well as claims that the environmental issues with livestock production are overstated. This has led to the development of 'nutritional density indices' which purport to show the nutritional value of livestock and alternative products in relation to their greenhouse gas emissions. However, the value of these indices are contested and they are very sensitive to the assumptions made.

Although competition in the markets is relatively fragmented at present, plant based protein and milk markets are becoming increasingly contested with many local and international players entering the market. The international players are also significantly increasing their scale of production. This may lead to the 'commodification' of both alternative milk products and protein extracts. The situation is rather different with chestnut flour, although the overall international supply of the raw product is dominated by China.

Domestically, New Zealand has a number of emerging oat milk brands. Due to lack of processing capacity, with the exception of one brand, oat milk is processed offshore. Use of domestic NZ oats also varies across the brands. There is no current commercial scale plant protein extraction occurring in New Zealand. However, a small number of New Zealand firms manufacture pea protein products using imported pea protein. There appears to be no commercial chestnut flour production in New Zealand and little evidence of its use in domestic food manufacturing.

Infrastructure

New Zealand currently produces oats and peas for domestic markets and export and a small quantity of chestnuts. The infrastructure exists to store, dry and grind the raw materials. Sophisticated packaging facilities are also available and through the chain there are well developed logistics. Therefore, currently, the main infrastructural gaps identified in New Zealand are at the processing level for oat milk and for plant protein extraction. This said, a large oat milk processing plant (initially 60 million litres per year) in Southland is expected to open later in 2023. However, in terms of protein extraction, not much has progressed other than the funding of a scoping study on the feasibility of establishing a pea/bean protein extraction plant. This study did conclude that a plant that could process 15,000 tonnes of peas and beans a year could be viable.

To supply the processing plants at the scale considered for the two products would require around 1,800 hectares of oats and 4,300 hectares of peas. The estimated initial level of investment required for the oat milk factory and protein extraction facility is around $60m and $50m, respectively.

Oats and peas and chestnuts currently struggle against competing land-uses though they offer non-economic incentives for growers as they are a low-carbon, sustainable crop option. A higher price could encourage these crops to expand on existing systems in a large number of arable regions of New Zealand, offering improved soil health, and diversified land-use, cropping rotations (for peas and oats) and income streams for growers.

Chestnut growing in NZ occurs on only a few hundred hectares. Chestnut trees take five to seven years to start producing the first nuts, and their optimum production age is reached after fifteen years. This makes production a medium, or even, long term investment.

Scale

To assess the viability of the alternative products at varying scales of production a spreadsheet tool was developed as part of the project. Key parameters such as raw material production costs, scale of production, level of integration, yields and processing costs were varied and the impact on the viability of the products (margin achieved) assessed. As expected, the viability of the various products is sensitive to the assumptions made concerning these parameters. However, under reasonable assumptions the model did highlight that production could be viable at a range of scales.

For individual or collective businesses, the viable scale of production is strongly correlated with the business approach taken. It may be possible for individual or groups to invest, for example, in proportion to their share of supply and still benefit from the potential scale economies of the larger plants. Alternatively, it may be possible to invest in the emerging brands, again at a range of scales.

Options for NZ growers

Construction of processing plants at scale within New Zealand can provide opportunities for growers as suppliers (either individually or, probably more viably, collectively) as demand for raw materials is likely to increase significantly. However, whilst there may be a margin based on security of supply and NZ provenance, this is unlikely to rise much above the cost of importing raw materials into NZ from competitor countries. This suggests that simply acting as suppliers of raw materials to processing plants is unlikely to bring about a marked shift in the returns from these crops for growers.

Growers can partner with international and/or national firms (either diversifying dairy and meat companies or specialist alternative protein companies) to enter the processing market. These partnerships can give NZ growers access to sophisticated marketing channels as well as an international customer base. This may increase the returns to farmers, but again there are challenges in achieving sufficient scale to be competitive against international competition as customers are unlikely to pay significantly more than international market prices even if provenance can be guaranteed.

Studies have identified that to move above the ceiling placed by the threat of imports of either the raw materials or the products themselves, requires the development of strong brands. However, there remains the challenge of being able to clearly identify the provenance of the final products

The fundamental challenge identified in the study is returning sufficient value back through the chain to generate returns to growers that stimulate production as well as compensate for potential risks associated with investment further down the chain.

It is likely that NZ will struggle to compete with the main competitors in global markets who are taking advantage of economies of scale, so differentiation, product innovation, and (nation) branding are important to consider when positioning possible products from New Zealand.

Project Purpose and Approach

The objectives for this project are to investigate the potential markets for new crops, their infrastructure requirements, and an indication of the supply requirements for an economic processing plant. The specified crops (products) include: Oats for milk; Peas (or beans[1]) for alternative protein; Chestnuts for flour for baking (breads, pasta) as well as inclusion in baby formula.

The project was developed in three related stages with each stage addressing a key requirement of the project brief.

1. *Current and potential markets, including an outline of potential products*.

   Available literature was used to identify existing and potential products and markets of interest for the three identified crops (Oats, Peas/Beans, Chestnuts). In addition the international landscape in terms of supply was also considered.

2. *Review of Infrastructure Requirements*

   In the second stage, through reviewing the available scientific and commercial literature, the infrastructural requirements in terms of storage, processing/manufacturing and logistics were identified for the key products. In addition potential gaps in the current infrastructure in New Zealand were identified.

3. *Scale of Supply*

   The final stage of the project involved an assessment of the likely scale of supply required to develop and maintain an economic processing unit for the chosen crop. This was determined using the information on identified markets (1) and infrastructure requirements (2). Two recent studies by AbacusBio (on oats) and PwC (on pea proteins) which examined viability of processing plants in New Zealand were drawn upon when considering scale issues. In addition to assess the viability of the alternative products at varying scales of production a spreadsheet tool was developed as part of the project. Key parameters such as raw material production costs, scale of production, level of integration, yields and processing costs were varied and the impact on the viability of the products (margin achieved) assessed.

[1] For simplicity, we generally refer to peas when considering plant protein. In the main the same considerations hold for Fava beans, although they do hold some advantages as a protein product over peas.

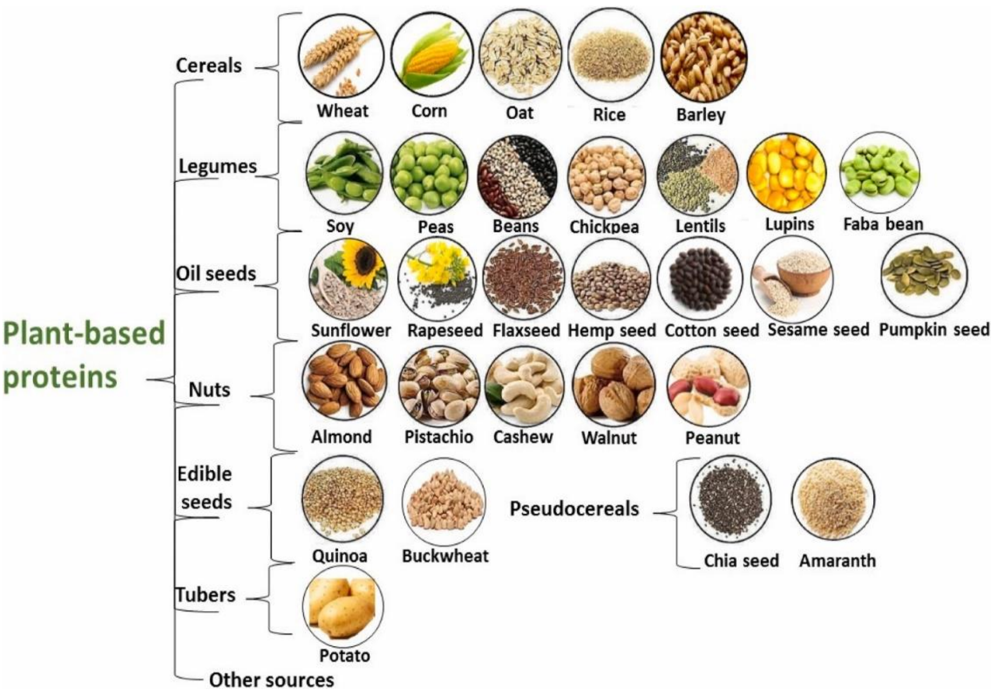
The Products

The three products chosen for analysis within this project are protein from peas/beans, oat milk and chestnut flour (from chestnuts). At the outset it is useful to clearly define the products that we are considering within the study and their place in the food system. In general they can be classified under plant-based protein, plant-based drinks (milks) and alternative flour.

Plant-based protein

Plant based proteins are just one of a number of protein-rich ingredients sourced from plants, insects, fungi, or through tissue culture that may replace conventional animal-based sources. As Figure 1 highlights, there is an extensive range of plant-based proteins including those derived from cereals (and pseudocereals), legumes, seeds (oil and edible), nuts and tubers. Proteins like tofu, have been around for centuries, but the origins of isolated plant proteins is more recent and dates back to the 1970s.

Figure 1. Plant-based proteins (not exhaustive)

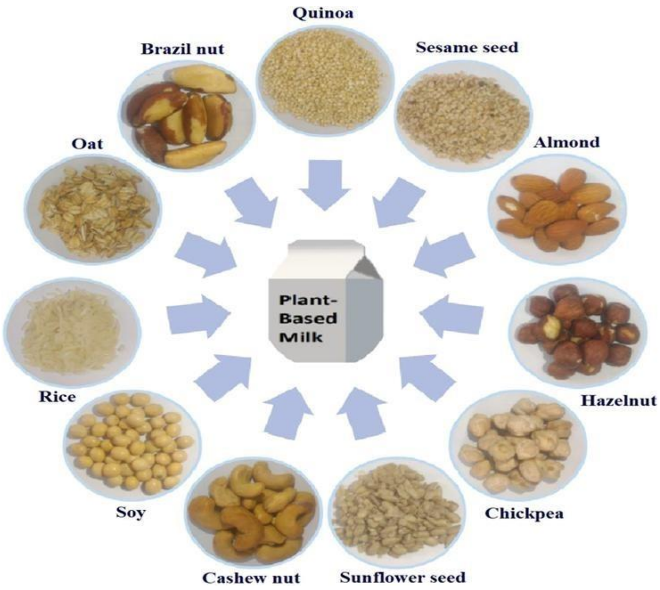


Source: Ahmad *et al.* (2021)

Plant-based Milks

As the name suggests Plant based milks are generally seen as a substitute for dairy milk. Figure 2 illustrates that, in general, similar plants are used to derive milk products and protein products. The heritage of plant-based milks also varies, beverages such as soy or almond milk have been available for many years, while oat milk was only developed in 1990 and entered world markets in 2016.

Figure 2. Examples of Plant-based Milks (not exhaustive)



Source: Silva et al. (2020

Alternative Flours

Wheat is the dominant source of flour globally, however, there are a wide range of alternative flours available. These include Almond, Buckwheat, Coconut, Chickpea, Rice, Potato as well as Chestnut flour. Alternative flours have been around for centuries, but the rising awareness of gluten intolerance has renewed interest in this product group

Specific Products

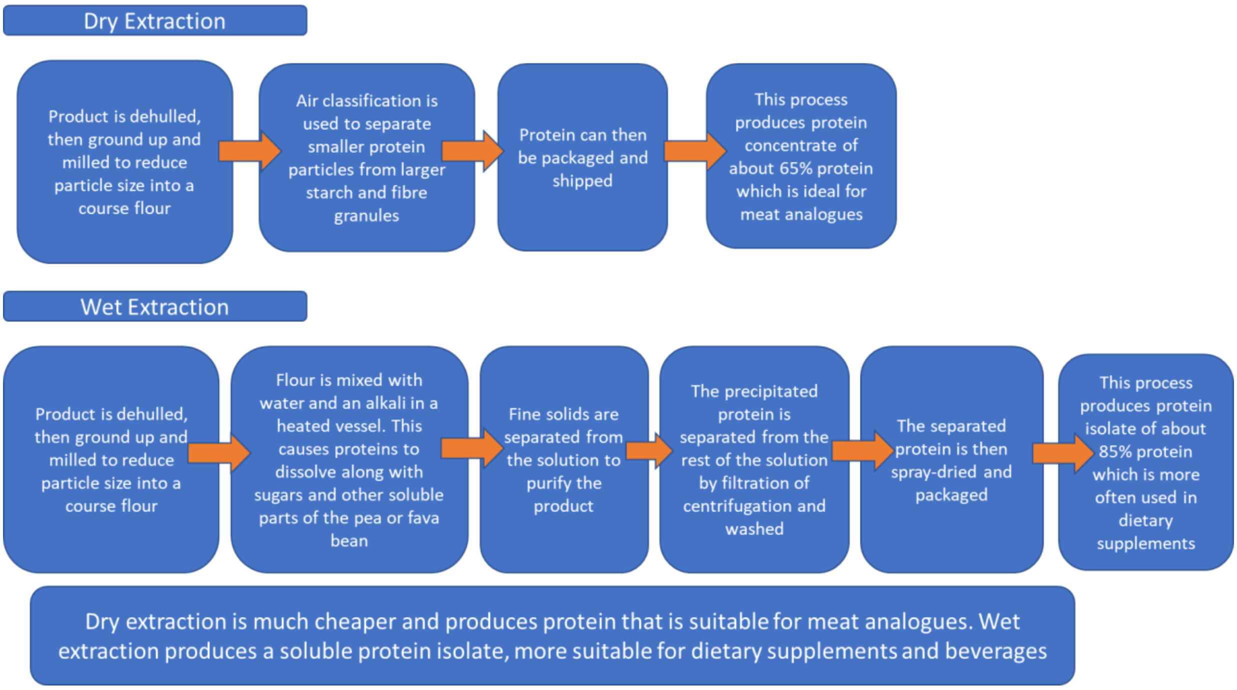
Table 1 and Figures 3 and 4, outline the processes by which the three key products of interest are derived, some of their key properties and examples of current uses. In terms of use, Figure 5 outlines the proportion of pea protein that goes into various products.

Table 1. Production Process, Example Properties and Uses of Selected Products

	Pea Protein	**Oat Milk**	**Chestnut Flour**
Process	Derived from whole peas through a 'dry' or 'wet' process (see Figure 3). Dry extraction is much cheaper and produces 65% protein that is suitable for meat analogues. Wet extraction produces a soluble protein isolate (85% protein), more suitable for dietary supplements and beverages. Three types of pea protein: textured, concentrated and isolated.	Derived from whole oat grains by extracting the plant material with water (often in an enzymatic process) See Figure 4.	Chestnuts are slowly dehydrated. When dry, the outer brown shell is removed in a shelling-machine. The shelled nuts still have a pellicle around the embryo. To remove this further drying is necessary. This makes the pellicle brittle. When atmospheric conditions are dry, a crushing operation will then shatter the pellicle off. The broken pieces of pellicle, which are very light, are removed by ventilation. Two stages of grinding then follow.
Properties	Pea Protein is a rich source of branched-chain amino acids, especially arginine, which improves blood flow and aids in muscle growth. It is easily digestible, vegan, hypoallergenic and can be well absorbed in a variety of diets. Fava beans are higher in protein and also branched-chain amino acids	Oat milk is vegan, lactose and soy and nut free. It is 100 per cent wholegrain. It is Gluten free. It is often fortified with B vitamins and minerals, ß-glucan content may lower blood cholesterol. It is also good for bone health. Can reach up to 36% of the daily recommended calcium intake.	The nutritional profile of chestnuts is unique among nuts. Chestnut flour contains high quality proteins with essential amino acids (4–7%), a relatively high amount of sugar (20–32%), starch (50–60%), dietary fibre (4–10%), and a low amount of fat (2–4%). It also contains vitamin E, vitamin B group, potassium, phosphorus, and magnesium.
Used for	Currently used for Meat substitutes (9%), Beverages (4%), Bakery Products (17%), Dietary Supplements (68%)	Manufactured in various flavours e.g., sweetened & unsweetened, vanilla or chocolate.	Sourdough bread, quick bread, cookies, extruded snacks, gel, and cake. Further refinement and additional uses can be developed by chemically, enzymatically, and physically modifying chestnut starch to obtain desired properties. It can serve as a replacement for cornstarch in applications where lower processing temperatures are used. The high sugar content and corresponding sweetness of chestnut flour can be used to create sweet foods without having to add sugar.

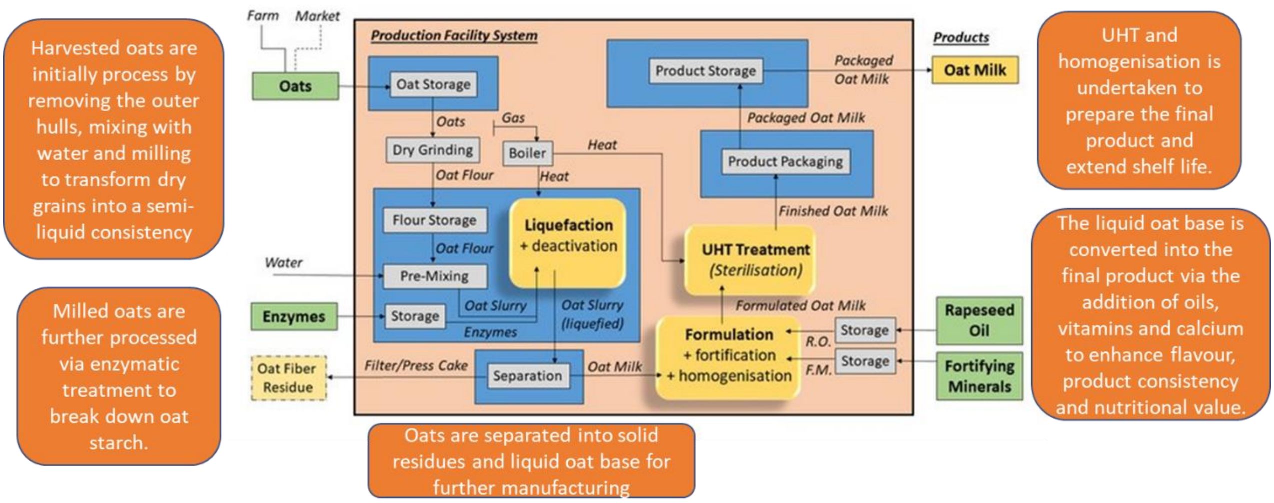
Sources: PwC (2022), AbacusBio (2022), Goldenfields (https://www.goldenfields.co.nz/chestnut_flour.php), Davison et al (n.d.)

Figure 3. Dry and wet protein extraction.



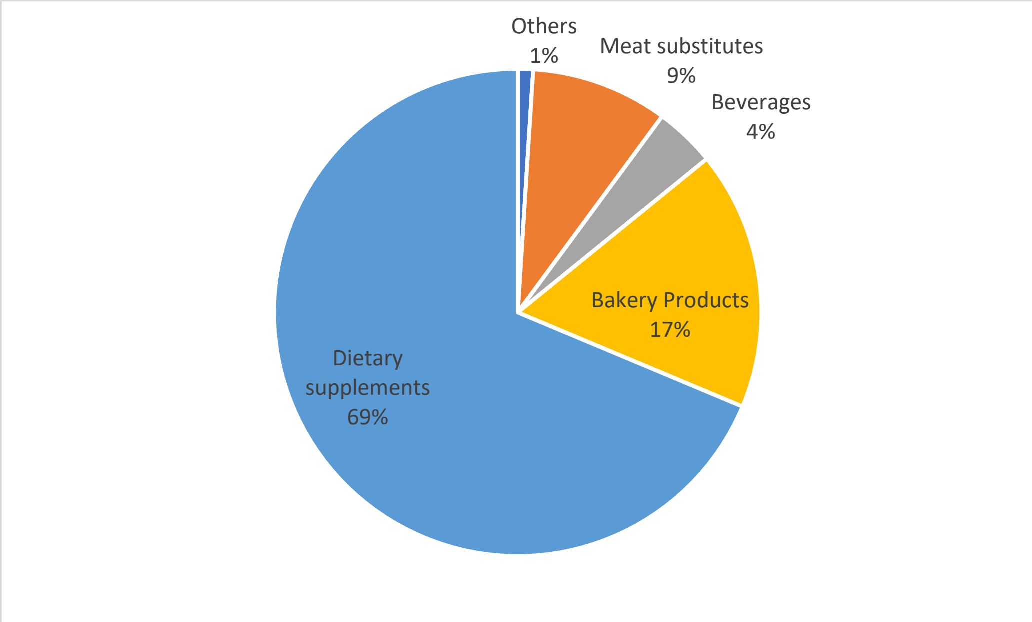
Source: Adapted from PwC (2022)

Figure 4 The production process for Oats.



Source: Figure, Ames (2020), Description AbacusBio (2022)

Figure 5. Current Distribution of products incorporating Pea Protein



Assessment of current and potential markets

Industry Overview

The plant-based food industry has shown remarkable resilience to the global turmoil that has occurred since the Covid pandemic took hold. Climate and sustainability concerns, coupled with consumer interest in plant-based diets and healthier lifestyles have fuelled a surge of product innovation in the plant-based industry worldwide. Consumers are seeking better, ethical, and more sustainable food, and alternatives have sprung up to meet demand. Health concerns are also driving growth in plant-based substitutes, whilst developments in production techniques have the potential to reshape the food industry. In 2021, steady momentum continued in the plant-based industry after rapid growth from 2019 to 2020 (GFI, 2022). If alternative meat and dairy products sales keep growing at current rates, the plant-based foods market could make up 10.6% of the global protein market by 2031, with a value of over $166 billion, up from $29.4 billion in 2020 (Bloomberg, 2022).

Industry Life Cycle

The dairy and alternative protein industry is in the growth stage of its life cycle. Total U.S. retail plant-based food dollar sales grew three times faster than total food sales in 2021 to $7.4 billion (GFI, 2022). Between 2015 and 2021, the number of new consumer goods launched within the plant-based segment grew by close to 700 per cent, accounting for 12 per cent of launches: more than 250 new SKUs were added to shelves in 2021 (GFI, 2022; Mintel, 2022).

Industry Demand Determinants

Demand for plant-based protein has been increasing worldwide and this trend is expected to continue. Market insights suggest that consumers in developed countries are replacing their consumption of animal products with alternative proteins. The global plant-based protein market grew strongly over the past decade, reaching a value of $9.5 billion in 2020 (PwC, 2022). Further growth is expected as consumers continue to shift towards healthier and more sustainable sources of protein.

The plant-based ‘milk’ segment is also growing strongly as consumers are preferring plant-based drinks for multiple reasons: taste, dietary requirements, health concerns, well-being, environmental awareness, animal sentience, and more. A market report prepared by the New Zealand Embassy in Washington (2022), found that consumers preferring non-dairy alternatives tended to be young adults both male and female. They were also more likely to live in urban areas rather than rural ones (MFAT, 2022).

There are four main drivers that are strengthening the demand for plant-based products: consumer preferences; environmental awareness; product research, development, and innovation; and governmental initiatives (PwC, 2022). Regarding the public sector, the initiatives seek to guide and support the industry in improving its standards and staying current in a very competitive market while at the same time motivating consumers to adopt healthier lifestyles. Governments of a large number of countries/regions including Denmark, Germany, the European Union, Norway, the United Kingdom, the United States, and New Zealand, have funded plant-based protein research (GFI, 2022).

In recent years, the desire for a healthier and more sustainable lifestyle has gained significant momentum. At the same time, consumers have decoupled the concepts of meat and protein, and they are more aware of animal welfare practices leading them to be more willing to try alternative protein sources (PwC, 2022). Awareness of the impact of livestock farming on climate, biodiversity and freshwater quality is driving the transition to a more sustainable model of food production. Plants, particularly legumes, have a lower environmental footprint than animal products, making them an ideal alternative to cultivating proteins. Given that perceived environmental advantage is one of the key driving forces behind increasing demand for plant-based protein Box 1 briefly considers the evidence supporting this perception.

Box 1: Environmental Considerations between Livestock and Alternative Protein Production

One approach adopted to compare across livestock and plant based products is Life Cycle Assessment (LCA). LCA is a standardised approach to evaluate a production system or product's resource use and environmental emissions. It covers multiple stages, including raw material extraction, production of farm inputs, and farm emissions, and extends to processing, transport, consumer use, and waste (Ledgard et al., 2016).

Recent studies have been undertaken on both meat and milk production in New Zealand (Ledgard et al 2021, Mazzetto et al, 2021). The estimated carbon footprint of NZ beef ranged between 20.59 and 22.78 kg of CO2-eq/kg of beef meat, depending on the assumptions made (Ledgard et al 2021). Between 90 and 95 per cent of emissions were estimated to occur from the cradle-to-farm-gate (mainly methane and nitrous oxide emissions), with the remainder from meat processing and all transportation stages. As may be expected the estimated carbon emission figures for sheep meat are lower than beef, ranging from 13.69 to 14.81 kg of CO2-eq/kg of product, again depending on the assumptions made. In the case of both beef and sheep production NZ emissions are at the lower end of global estimates. For dairy, Mazzetto et al (2021) found that New Zealand is still the most efficient milk producer at 0.77 kg CO2e per kg FPCM[2]-which is 48 percent less than the world average - 1.47 kg CO2e per kg FPCM (Mazzetto et al., 2021).

Whilst New Zealand is estimated to be among the most efficient producers of livestock products in terms of CO2-eq emissions, evidence suggests that emissions are lower from proteins derived from crops. For example, although not specifically calculated within a New Zealand context, some estimates for peas place emissions as low as 1.3 kg CO2-eq (Heusala et al, 2020). Whilst other estimates in the literature are higher at 4 kilograms of carbon dioxide equivalent per kilogramme of product, this is still significantly lower than even the most efficient beef or lamb production. No specific LCA has been undertaken of oat milk in New Zealand, however Oatly provide a series of independently verified estimates of the carbon emissions from their production in a European context. These range from 0.27 kg CO2e /kg product for Oatly Enriched Oat Drink Ambient, to be sold in Sweden to 0.51 kg CO2e /kg of Oatly Barista Oat Drink sold in the UK.[3]

[2] If land-use change is included this figure rises to 0.91 due to emissions associated with land moving out of forestry into dairy in NZ.

[3] The emissions estimate for a UK brand PureOaty is estimated to be 0.29 kg CO2e /kg product

Box 1: Continued

Overall, if we take these figures for illustrative purposes, the difference in CO2-eq emissions between Oat milk (as estimated by Oatly) and New Zealand dairy ranges between 1:3 and 1:1.5. For protein, even when taking the higher estimate of 4 kg CO2e /kg product for peas, the ratio with beef is 1:5. Globally these ratios are likely to be even further in favour of plant based products.

Beyond emissions, there is considerable evidence that in terms of potential wider environmental impacts such as water use and land requirements plant production also has a lighter footprint (Heller and Keoleian, 2018; Ritchie and Roser, 2021). For example, one kilogramme of beef is estimated to require 7280 litres of water and 1636 square meters to create compared to only 1780 litres and 34 square meters for peas (Heller and Keoleian, 2018; Ritchie and Roser, 2021). Although it should be noted these figures are not specific to New Zealand farming systems.

Reviewing the literature more generally, there are a wide range of estimates of the environmental footprint of both plant based and livestock proteins, often due to the assumptions made in the calculation process. However, there is general consensus that in terms of *per kilogramme of product*, pea and faba protein and oat milk have a lower environmental footprint in terms of land requirement, water use and CO2-eq emissions than their livestock derived equivalents (Roos et al). However, the debate has developed to one of considering whether per kilogramme (or litre) of product comparisons are correct due to potential nutritional differences between plant and animal products. For example an industry funded study undertaken in NZ highlights the nutritional difference between available plant-based drinks in New Zealand and dairy (Smith et al, 2022). That is comparisons on a per kg basis might give different results if the health effects of the different products were taken into account.

One of the earlier efforts at 'correcting' for the nutritional quality of products was Smedman et al (2010) who developed a nutrient density to climate impact (NDCI) index which basically takes into account the proportion of the recommended daily intake of 21 selected nutrients that the product supplies as well as the number of nutrients in the product that provide more that 5 per cent of the daily recommended intake. The index is calculated according to the following formula:

Box 1: Continued

$$\text{Nutrient density of food item Y} = \sum_{21\ \text{nutr}} \left(100 \times \frac{\text{Amount of nutrient X in 100 g of Y}}{\text{Recommended intake of nutrient X}}\right) \times \left(\frac{\text{Number of nutrients in Y} \geq 5\% \text{ of rec. intake}}{21}\right)$$

$$\text{NDCI index} = \left(\frac{\text{Nutrient density of Y}}{CO_2\text{e for 100 g of Y}}\right)$$

The Nutrient to Climate Impact (NDCI) index is Nutrient Density divided by the CO_2e for 100 g of the food item.

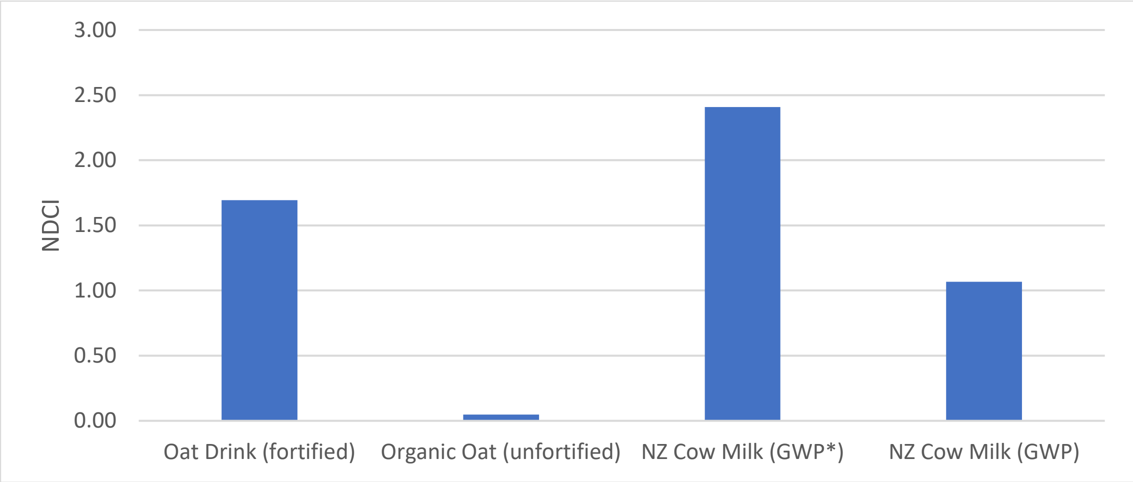
The impact of considering nutrient density can be seen in Figure 1 Box below which provides a comparison of dairy milk with oat based drinks. Under the NDCI formula (and using a mid-Oatly estimate of 0.38 and a NZ dairy estimate of 0.77) it is clear that cows milk significantly outperforms unfortified oat milk (whichever way methane emissions are treated in the calculation). Though not shown, this result is repeated across other plant drinks such as soy and almond. However, as noted by Roos et al, fortification can produce plant-based drinks which are much more similar to cow milk. The impact of this is marked for oats, where, as the figure shows, its lower estimated emissions per unit of product coupled with its enhanced nutrient profile following fortification mean that its NDCI is higher than that of cows milk when GWP is used, though still lower when GWP*, which attempts to take account the differential effect of methane, is used.[4]

This supports the conclusion of Roos et al who noted that ‘If plant based alternatives are fortified to resemble dairy milk, they score very similarly to dairy milk in terms of the nutrient density, and the environmental advantage of plant-based alternatives will remain.’ However, Roos et al also note that ‘it is unclear whether the nutrient content reached by fortification is ‘the same’ as ‘natural’ occurrence of nutrients in the diet. This is another question in need of more discussion and investigation.’

[4] GWP* has been proposed as a measure of the global warming potential recognising that methane, unlike carbon dioxide, is a short lived gas and is broken down in the atmosphere. Put simply, under certain circumstances use of GWP* is likely to lead to a reduction of emissions from livestock production in particular because of the significant contribution of methane to overall emissions. Whilst not officially adopted internationally as a measure, its impact on emissions of dairy production is highlighted in the figure for illustrative purposes. For more details see Allen et al (2018)

Box 1: Continued

Figure 1 Box: Example of NDCI for Oat Milk and Cow Milk



Source: Kite Consulting NDCI calculations adapted by authors for NZ dairy milk emissions

Whilst NDCI figures have been included here for comparative purposes it should be noted that there is considerable debate about the validity of the index. In particular, Roos et al note that Scarborough and Rayner (2010) highlighted the susceptibility of the index to what may be seen as the arbitrary decision as to the choice of what contribution of daily recommended amount should be taken as the threshold figure. For example, using the data of Smedman *et al.*, they showed that when the threshold is set at a figure lower than five per cent, soy drink actually has the highest NDCI score. When it 5 or 10 per cent then milk is highest and when it is over 20 it is orange juice that achieves the highest score. Other, more sophisticated approaches to take account of nutrient density have been developed (for example, van Dooren et al., 2017), however, Roos et al note that a challenge often found with these is that their complexity makes it difficult to interpret the findings. Overall a major issue is that nutrient density indices can be created in many different ways, which will strongly affect the results (Saarinen et al., 2017).

Mazzarti et al, 2021, when explaining why they had not considered nutrient indices in their recent study on beef and lamb sum up the difficulties with the approach: 'However, based on consultation with nutrition experts from the Riddet Institute and AgResearch, it was concluded that the use of nutritional indices that do not acknowledge the nutrient bioavailability and/or protein quality are not recommended for the comparison between different categories of food (e.g. meat versus vegetables). More extensive nutrient profiling needs to be conducted to assess the relationship between a nutritional index and the footprint associated with different protein alternatives.'

To the same extent that consumer preferences are changing, private investment is increasingly supporting the development of new techniques to satisfy the demand for plant-based and alternative proteins (Euromonitor, 2021). This not only includes the headline capturing growing of meat in laboratories, but also improving the processes of extracting proteins from grains and pulses to make them available as high-value ingredients for the food industry. It is clear that the food industry is constantly working on introducing an extensive array of plant-based products in supermarkets. In addition, plant-based products continued to expand across foodservice channels; chains like McDonalds and Starbucks are including plant-based options in their menus around the world (GFI, 2022).

A particular factor promoted the consumption of plant-based proteins and drinks during the COVID-19 pandemic, shelf life. Since beef and dairy products require refrigeration to extend their shelf life, and even then, they cannot go beyond a week, consumers around the world found plant-based products to be a perfect alternative. Facing the fear of lengthy quarantines, consumers were looking to stockpile food and goods for an undetermined amount of time, so they looked for items that could last for the long haul (MFAT, 2022). Plant-based milks, for instance, were among the first products cleared off the supermarket shelves during the pandemic.

The upward trend in sales of alternative milks continued. Plant-based drinks sales in the US amounted to $13.2 billion in 2020; 20% of the value of dairy milk (MFAT, 2022). US retail sales of oat milk - which barely registered in the US market in 2016 - rose 50.52% in 2022 to reach $527.44m (Food Navigator, 2022). Oat milk's market share has also grown over soy and almond milk in Europe. In terms of Chestnut flour, the fact that it is gluten free means that demand could develop in that market segment. Until now, Gluten Free food producers in New Zealand have not been using chestnut flour as an ingredient. Potentially this is a gap that could be filled. Gluten-free products are essential for people with Coeliac disease and for those who have a more generic gluten intolerance. Given that following a gluten-free diet is the only option to control their condition, availability of GF products is essential to their wellbeing.

Coeliac disease (CD) is a chronic autoimmune disorder triggered by recurrent exposure to gluten and gluten like proteins present in wheat, rye, and barley in genetically susceptible individuals (Lindfors et al., 2019). Approximately 1% of the adult population in Australia and New Zealand suffer from CD or have more generic gluten intolerance (Ho et al., 2021). A rigorous gluten-free diet has been considered the only effective treatment for CD (Itzlinger et al., 2018). Those suffering from CD rely on gluten-free products for them to purchase, either as ready-to-eat foods or as ingredients. (Vriesekoop et al., 2020).

Flour and bread, with flour being its main ingredient, are fundamental elements in the diet of all societies. Bread, for example, is the most important staple food of humans; after thousands of years, it remains the most regularly consumed food in the world due to its convenience, portability, nutrition, and taste (Valavanidis, 2018). People suffering from CD and gluten intolerance follow this trend; however, they must look for GF alternatives as to the basis of their diet. GF products in New Zealand are currently made with corn starch, rice flour, tapioca starch and potato flour.

Table 2. Market Research Estimates of Demand Growth Rates.

Category/Product	Cited Compound Annual Growth Rates (%)
Plant based Proteins	7.2 - 7.4 (up to 2027)
Pea Protein	13.5 (2020 - 2025)
Plant based Milks	8.0 – 13.0 (up to 2029)
Oat Milk	9.8-13.4 (2020-2027)
Gluten free products	8.1 (up to 2025)
Chestnuts	2.2 (up to 2025)

Source: Various market research reports

Whilst the demand for alternative proteins appears very strong, it should be noted that for alternative meats in particular, growth has plateaued and in some case declined in 2022. This has led to questions about the place of these products on the market and the longer term growth opportunities. Industry commentators have mixed views as to whether there is a fundamental shift in the demand for these products or whether it is just a blip in the longer term upward trend (Harvey, 2022). Deloittes (2022) attribute the change in part to the fact that the addressable market is not as high as some had predicted. In particular they cite the challenges caused by high inflation and food price inflation in particular mean that fewer consumers are willing to pay a premium for the alternative meat products. In addition, their research found that more consumers were questioning the health and environmental benefits of alternative meat products (Deloittes, 2022). This is interesting given that the evidence for environmental benefits at least is quite compelling as highkighted in Box 1.

Industry Competitive Landscape

Overall demand for alternative proteins and gluten free products is very strong and is forecast to remain so for the near future at least. This would suggest that pea protein, oats and chestnuts may be attractive markets to enter. However, demand is only one part of the equation and there is a need to consider the competitive landscape for these products. This includes consideration of the strength of possible substitute products (of which as we have highlighted earlier there are a number) as well as existing and potential supplier competition.

Whilst New Zealand, may not have an existing pea protein capability, the global pea protein market is highly competitive with many local and international vendors. According to PwC (2022), established players such as DuPont, Roquette, Ingredion and Cargill hold sizeable market shares which have emerged due to their scale of operations, high levels of investment as well as brand value. Roquette for example have announced plans to build a $650 million plant in Canada, capable of processing 125,000 tonnes of peas per year.

Similarly, it has been observed that quietly the plant-based milk sector has become a fiercely contested consumer market. This has included the entrance of multinationals such as Nestle (who in 2021 launched a pea milk), as well as major Dairy companies such as Danone and Yili. The Financial Times (FT) note that '… dozens of start-ups and many of the biggest multinationals are investing in products that mix the latest in food science with a shift in consumer tastes towards products seen as healthier and more sustainable' FT (2021). In terms of oat milk, the FT quotes one venture capitalist in agricultural technology who says margins will inevitably fall. "The barriers to entry are minimal and it's incredibly competitive," he says. "[Rivals] are going to go for Oatly's gross margins." This said currently the plant-based drinks market does not have the high levels of concentration seen in some other parts of the food and drink industry. For example, Table 3 highlights that according to Euromonitor the largest 5 companies in the sector currently account for slightly less than a third of the market

Table 3. Major competitors in the plant-based drinks segment in 2021.

Company	Global market share
Danone	11.8%
Heibei Yangyuan	8.0%
Blue Diamond	5.4%
Coconut Palm Group	4.4%
CEBA	3.5%

Source: Authors' elaboration based on data from Euromonitor 2021

It may be argued that the scale of pea protein production has virtually commoditised the product which has significant implications for those who wish to enter the market. However, PwC (2022) also note that increasing demand for pea protein, for example in animal feed, is expected to intensify competition for users as well as manufacturers.

In terms of its use as a meat alternative, the largest five companies again account for just about a third of the industry (Table 4).

Table 4. Major competitors in the meat alternative segment in 2021.

Company	Global market share
Monde Nissin	8.2%
Beyond Meat	7.4%
Kellogg	6.9%
Impossible Foods	6.3%
Nestlé	3.9%

Source: Authors' elaboration based on data from Euromonitor 2021

Chestnut flour is in rather a different situation. Globally supply of chestnuts is dominated by China and the largest suppliers. However, clearly the technology is freely available and any upturn in the sector is likely to attract new entrants with few barriers to entry.

In order to provide more insight into the markets for the products under consideration, Appendix 1 provides an overview of the situation in key international markets for New Zealand

New Zealand Situation

In New Zealand, the amount spent by households on plant-based milk almost tripled from $52 million in 2017 to $144 million in 2019 (Nash, 2022). In the first quarter of 2022, sales grew 58% over the preceding period, and as in the US, oat-milk has already overtaken soy, and after almonds, it is the second most popular plant-based milk (Stuff, 2022).

In terms of the competitive environment, we found in the national retail environment 13 oat milk brands, 5 of them are produced by local companies (Table 5). In terms of the wider competitive environment, Figures 6 and 7 highlight the array of plant based milks available in stores in Christchurch, NZ and illustrate the contested nature of this segment of the drinks market.

Table 5. Domestic and International Oat milk Brands in New Zealand (as of July 2022)

Brand	Location	Package	Price	Channel	Notes
Otis	Dunedin	1L carton	$5.50	Online & Countdown	Made with 100% kiwi oats – exported to Sweden for processing and then returned
All good	Auckland	1L carton	$4.99	Online & New World	Made in NZ from Finnish and Swedish oats
Boring	Hawke's Bay	1L bottle	$5.00	Online & Countdown	NZ oat milk company making oat milk in NZ with NZ oats.
Little Island	Auckland	1L bottle	$5.99	New World	Made in NZ from local and imported ingredients – organic oats
Sunny South	Auckland	1L carton	$4.95	Online + shipping	NZ Company producing offshore (UK)
Minor figures	Australia	1L carton	$5.69	Online & New World	Oat milk made in Australia with Australian oats.
Sanitarium	Australia	1L carton	$3.65 $4.20	All supermarkets	Australia made from at least 97% Australian ingredients.
Oatly	Sweden	1L carton	$5.00	Countdown	Made in Sweden from local ingredients.
Vitasoy oat milk	Australia	1L carton	$2.99 $4.20	Pack n Save, New World	Made in Australia from Australian grown oats
Alpro	UK	1L carton	$5.50	Countdown	Made in UK from imported and local ingredients
Isola Bio	Italy	1L carton	$5.00	Countdown	Made in Italy from organic local ingredients
Good Hemp	UK	1L carton	$6.00	Countdown	Made in UK from imported and local ingredients
Pure Harvest	Italy	1L carton	$5.69	New World	Australian owned & made with organic ingredients.

Figure 6 Plant-based "milks" available in a convenience store in Christchurch, NZ.

Figure 7. Plant-based "milks" available in a discount store in Christchurch, NZ

As noted earlier the majority of current pea protein use is for dietary supplements. The following table presents some of the pea protein products available on the market in New Zealand and provides insights into the nature of the market for these products. Again, there are a mixture of domestic and international brands available although as the protein isolate itself is not produced in New Zealand this is sourced internationally.

Table 6. Example of Pea protein products available in NZ (as of July 2022)

Brand	Location	Product	Price/KG	Chanel	Notes
NZ Protein	Auckland	Pea Protein Isolate	$37.00	Online & Countdown	Made in NZ from premium-quality natural golden peas grown in Canada
Nothing Naughty	Waikato	Premium Pea Protein	$49.95	Online	Made in NZ from imported peas
Natures Sunshine	Auckland	Love & Peas protein	$118.45	All supermarkets	Made in NZ from imported peas
Horleys	Masterton	Peas protein	$94.00	Health 2000/ Countdown	Made for an NZ company in Malaysia
Go Good NZ	Auckland	Plant Protein Isolate	$39.00	Online	Made for a NZ company in Belgium from European beans
Balance	Auckland	Plant Protein	$69.90	Health 2000/ Supermarkets	Made in NZ from imported peas
Martin & Pleasance	Australia	Vital Protein	$72.50	Health 2000	100% Pea Protein Isolate, Natural Vanilla Flavour, Thaumatin & Monk Fruit
Nuzest	Australia	Lean Protein for kids	$99.00	Nutrition retailers	Blend of super greens (peas), fruit, veggies and berries.
PranaOn	Australia	Golden peas protein	$76.49	Nutrition retailers	Power Plant Protein combines three plant based proteins enhanced with branched chain amino acids
Amazonia	Australia	Peas isolate protein	$77.90	Nutrition retailers	formulated with certified organic sprouted and fermented plant protein for optimal digestion.
Aussie Bodies	Australia	Peas protein	$75.50	Health 2000	Mix of peas, brown rice and chia seeds
Musashi	Australia	Peas and hemp protein	$77.60	Health 2000/ Supermarkets	blend of pea protein, brown rice, chia, and sacha inchi.

In New Zealand there are also a small number of companies who are currently manufacturing final products using imported pea and bean proteins. These include Nothing Naughty, Sunfed, Plan't Foods, Off-Piste and Let's Eat. They make an array of products containing plant protein as the main ingredient including plant-based nuggets, burger patties, 'chicken-free' chicken, jerky, and other meat analogues. Additional products include cheese analogues and dietary supplements (PwC, 2022). In terms of the cost of this imported protein, PwC (2022) cites one manufacturer who states that the price of imported protein was at that time $6400 per tonne and had risen from around $5000 over a few months. The cost of imported protein is important to understand as this sets a benchmark against which any domestic production would have to compete.

The domestic chestnut flour market is virtually non-existent. We found one retail supplier, but they had discontinued selling chestnut flour as they were unable to source domestically produced product. This was supported by the fact that we found a database with four growers, only one of which remained in business. As for imported chestnut flour, we were able to find just two options: Eco Andes Chestnut flour, from Spain; and Golden dried chestnut meal from China, at a price of $36.00 per Kg.

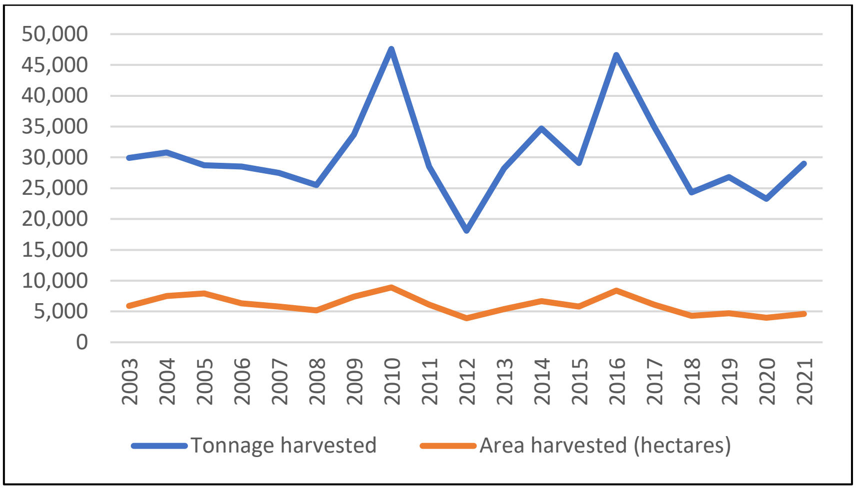
New Zealand Raw Materials

Oats

Oat production in New Zealand is concentrated in the South Island; Southland, Ashburton and Selwyn account for more than one half of the national production. Between 2003 and 2021 the area of oats grown has fluctuated from under 5,000 to nearly 10,000 hectares and production has fluctuated from under 19,000 to over 45,000 tonnes (Figure 10). In 2021, oat growers harvested 29,000 tonnes from 4,600 hectares. In the previous year production was split roughly 55:45 between grain oats and feed oats (Abacusbio, 2022). Soil characteristics, precipitation, sunlight hours and a long growing season are important factors that contribute to the ability to achieve high yields of quality grains (NZFF, 2022).

New Zealand has always been an exporter of oats (initially largely for horse feed). That said, in global terms New Zealand is a small exporter, in 2020 it accounted for less than one per cent of the world market. This means it is ranked 19th in terms of global exporters of oats. The top three exporters in the world are Canada, Finland and Australia who account for 50, 10 and 5 per cent of exports, respectively. The main importers are the US (38 per cent), Germany (14 per cent), the Netherlands (5.5 per cent) and China (4.5 per cent) (OEC, 2022).

Figure 8.Oat production in New Zealand

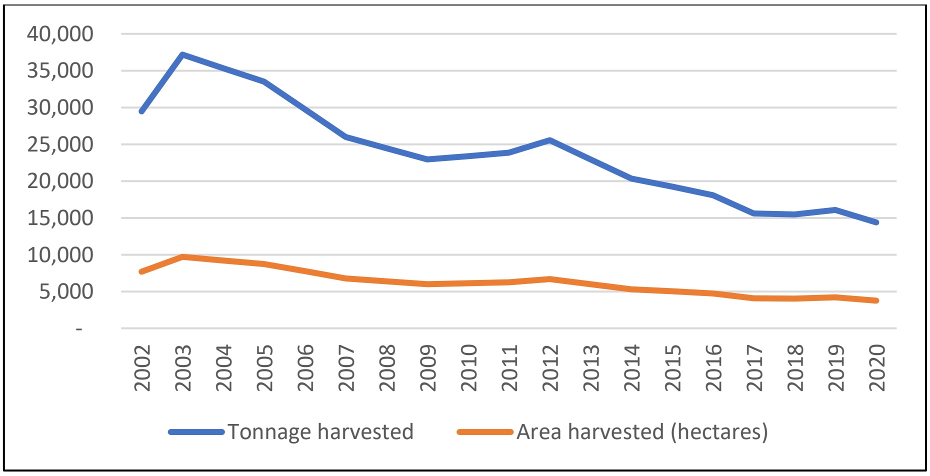


Source: NZ Stats (2022)

Peas/Beans

Although subject to some fluctuations, pea production in NZ has declined since 2003, when 37,182 tonnes were harvested on 9,708 ha in the country to just 14,389 tonnes on 3,757 ha in 2020 (Stats NZ, 2022). This has also coincided with a significant reduction in the number of growers. Peas are currently grown primarily in Hawke's Bay and Canterbury, not necessarily because there are the only suitable areas in New Zealand, but due to proximity to a freezing facility. Most peas grown in the country are sold as frozen peas and roughly two thirds of the total value of exports (which was $108 million in 2021) comprised frozen peas (Fresh Facts, 2021). However, white peas (also known as field peas) are also grown and used for animal feed or seed.

Figure 9. Pea production in New Zealand



Source: NZ Stats (2022)

Chestnuts

The New Zealand chestnut industry is extremely small and, as with much of the nut sector, mainly consists of hobby growers. Chestnut trees can grow successfully across most of New Zealand. There are some plantations in Northland, Wairarapa, Horowhenua and Canterbury.

Fresh chestnut production topped 350 tonnes in 2019. It was produced by about 100 growers on an area of 142 hectares (NZ HEA, 2021). Small quantities of fresh nuts were exported; however, the world markets are now shifting away from fresh to frozen nuts as well as chestnut flour and crumbs. Unlike other nuts, chestnuts cannot be stored, due to their high-water content. Consequently, they are treated as a fresh, perishable product, with a limited shelf-life (Rotorua LUD, 2020). Growers would need large investments in technology to provide solutions for processing and storage.

The recognised grower body is the New Zealand Chestnut Council. The New Zealand Chestnut Council's aims are to encourage, promote and advance New Zealand's chestnut industry, which includes promoting the sale and consumption of fresh and processed New Zealand grown chestnuts, both in New Zealand and overseas (NZ HEA, 2021). Unfortunately, chestnut growers are shifting to other land uses, and those who still grow it often do so as a hobby.

Chestnut trees take five to seven years to start producing the first nuts, and their optimum production age is reached after fifteen years. This clearly differentiates them from the annual crops of peas and oats. The high up-front investment costs and delay in production increases the risks of chestnut production when compared with annual crops.

Intercropping

Rather than choosing one specific product to grow, there is the option of adopting an intercropping strategy. Previous findings have found that the oat-pea combination can deliver significant benefits while being more profitable than oats or peas grown as monocrops (SERF, 2021). If chestnut trees are included in the cultivation program, it would be very interesting to develop a model that combines the three products, in this way the trees can provide shelter for arable crops while absorbing significant amounts of carbon from the atmosphere while reaching their productive age. However, growers must be willing to undertake additional requirements of raising a mixed grain intercrop such as making modifications to farm equipment and separating the oat-pea mixed grain after the harvest (SERF, 2021).

A note on returns

AbacusBio (2022) estimated that there were 10,700 hectares in Southland alone that would be suitable for growing oats and Thomas *et al* (2020) highlight significant areas of the country suitable for the production of peas and chestnuts. Therefore in principle, production could be expanded to meet increased demand from new end-uses. However, as can be seen above, the main crops associated with our products are currently limited in terms of their reach and, in some cases areas are actually declining. Largely this is the result of economic factors that mean the returns generated from existing end-uses make it hard for them to compete for land against other enterprises. These include Dairy, but also more relevantly other arable crops (including seed crops). This does raise the question as to what the returns from supplying alternative uses would have to be to encourage increased production. PwC (2022), through discussion with stakeholders, suggest that if dried peas return a similar margin to ryegrass seeds then farmers could be sufficiently incentivised to scale up growth. At the time of writing (mid 2022) they estimated that a 25 per cent increase in the price per tonne of peas, and a 100 per cent increase in the price of fava beans would be needed to generate the same return.

Infrastructure Requirements

Examining the current supply chains in New Zealand for the selected products gives some indication of the current infrastructure as well as highlighting potential issues. Table 7 summarises the information described earlier concerning the nature of oat milk being produced in New Zealand. As shown, to the best of our knowledge, currently only one of the main producers is actually processing oat milk in New Zealand (and currently production is relatively small, though growing). In addition, two of the main brands are sourcing their oats from overseas as well. One argues that it makes more sense environmentally to source the oats from overseas rather than shipping oats from New Zealand to be processed and then shipping the finished product back. The other is an organic product, suggesting that sourcing organic oats in New Zealand may be a challenge.

Table 7. Current chains for main NZ Oat milk brands

Brand	Oat Production	Oat Milk Processing	Final Product
1	NZ	NZ	NZ
2	Finland/Sweden	Finland/Sweden	NZ
3	NZ	Sweden	NZ
4	UK	UK	NZ

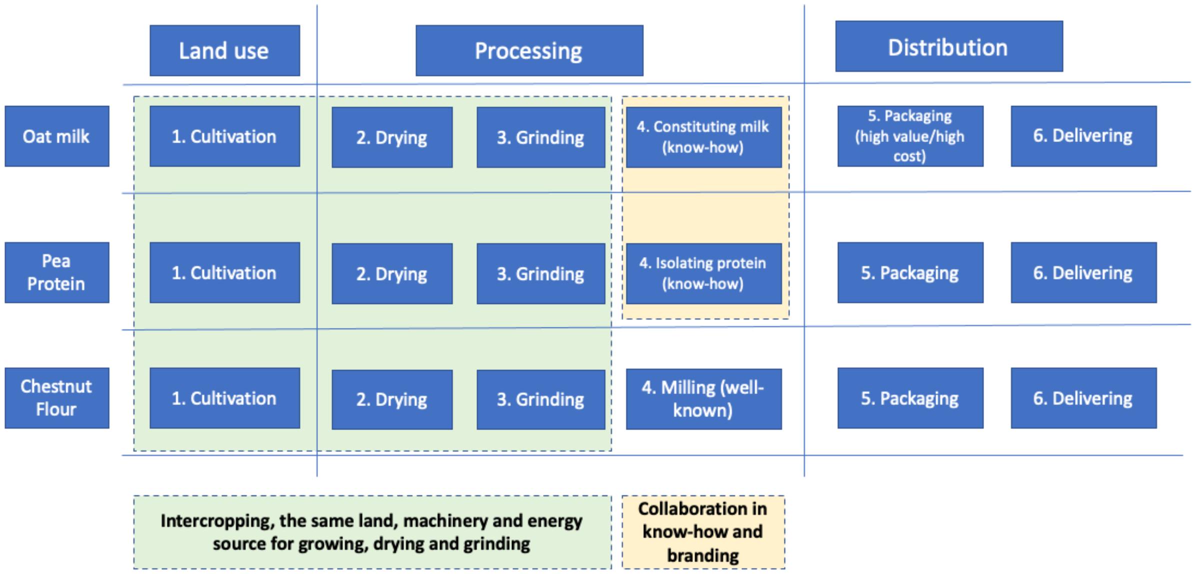
The situation for pea protein is clearer in the sense that as there is no commercial scale extraction facility in New Zealand, all distributers of pea protein powders or manufacturers of products derived from it rely on imported protein. Therefore, in the pea protein supply chain we have the raw material (peas) produced in New Zealand (with handling and storage facilities etc.) and manufacturing capability, but no processing capacity.

For chestnuts, as discussed earlier, actual production is only in the low hundreds of tonnes and to the best of our knowledge there is now no commercial chestnut flour production in NZ. However, there is extensive flour milling capacity (discussed below) within NZ, which presumably could handle chestnuts were it to be lucrative to do so. In addition, to the best of our knowledge, there are currently no food manufacturers (of gluten free products or others) utilising imported chestnut flour.

If we conceptualise the stages in our supply chains as in Figure 10, it enables us to consider the various stages in more detail. Domestically we have cultivation (albeit on a small scale for chestnuts), there are also facilities for drying the product and grinding as well. For example, most New Zealand oats are processed through the Harraways factory in Dunedin, where all oats are milled and de-husked, which can be seen as a first step to any further processing for oat milk (AbacusBio, 2022). There are also facilities that could be contracted for packaging the products.

Therefore, the real gap is in the processing (constituting) of the oat milk and the isolation of protein.

Figure 10 Conceptualisation of stages in production of Milk, Protein and Flour

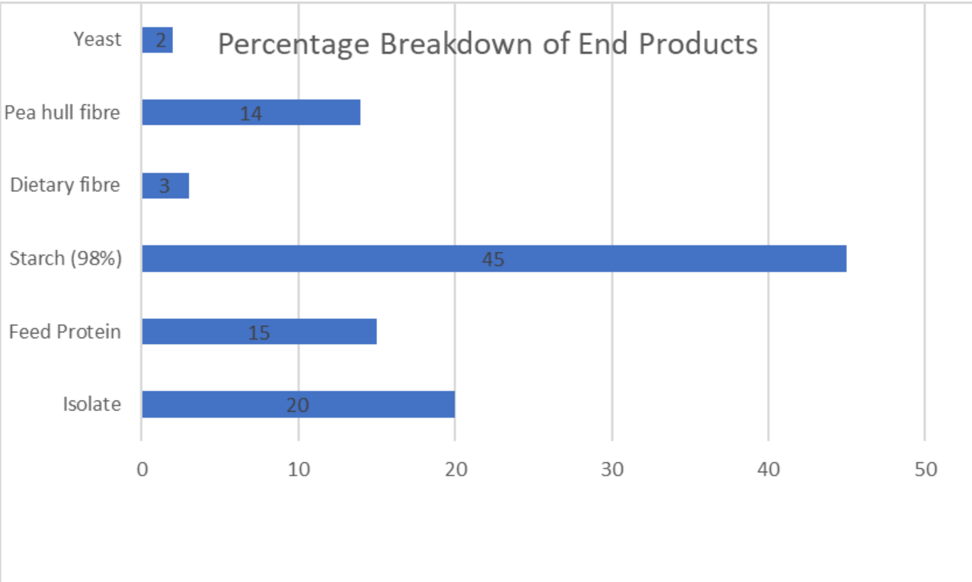


There is widespread awareness of these potential gaps in the value chain within New Zealand and work has been undertaken to consider the viability of both oat milk processing and pea protein extraction plants.

In relation to protein extraction, and considering New Zealand as a whole, a recent study estimated that a 15,000 tonne a year plant was feasible in New Zealand and that construction of such a plant would cost in the region of $50 million (PwC, 2022). Assuming an average yield for peas of 3.5 t/ha this would require around 4,300 ha of peas to supply the factory – nearly double the current acreage grown in NZ. More developed is the planned construction of an oat milk processing plant in Makarewa, Southland. Estimates as to the cost of the factory appear to be between $50 and $60 million and it was stated that it would produce 40 million litres of oat milk initially. According to analysis by AbacusBio (2022) a 40m litre factory would require around 9,200 tonnes a year of oats (assuming that a litre of milk takes 230 grammes of oats[5]). At an average yield of 7.5 tonnes per hectare they estimate that this would require around 1200 hectares of oats to supply it. More recent information on the factory suggests that it open later in 2023 and will produce 60 million litres a year (NZFF, 2022), which according to the AbacusBio calculations, would require the production from around 1,800 hectares of oats. Companies that have established a brand in New Zealand, but have been making the actual milk offshore are looking to source milk from the factory. For example, Sunny South and Otis milk appear to have signed contracts committing to purchasing milk from the factory.

When considering pea protein extraction it is important to note that protein is only a relatively small proportion (roughly a fifth) of the final product and a number of by products are produced. Figure 11 highlights that the largest by-product is actually pea starch (representing nearly half of the output from the production process).

Figure 11 Percentage Breakdown of products from Pea Protein Isolation Process



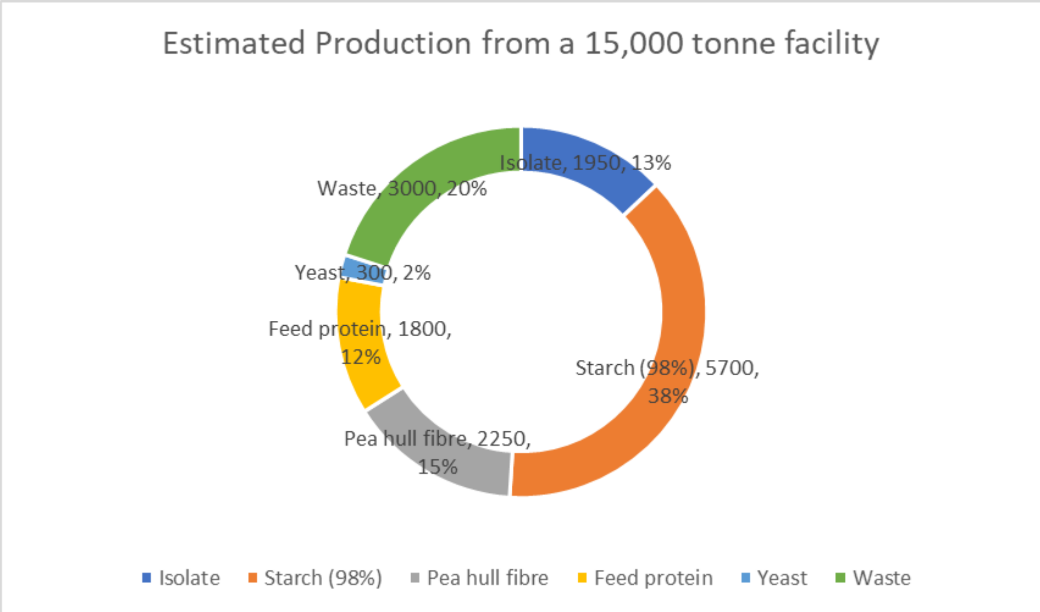
Source: Legume Innovation Network (2021)

For illustrative purposes we examine the distribution of products that are likely to be derived from a 15,000 tonne plant. As highlighted in Figure 12, the major by-product of isolating protein is starch. PwC (2022) note that opportunities for economically utilising the pea starch are increasing as it has useful properties. This would however require facilities that are able to handle starch products and given the short life of the products it needs to be

[5] Interestingly, elsewhere Oatly state that each litre of oat milk only requires 100 grammes of oats

relatively close. Currently there is one starch factory in New Zealand which is located near Auckland.

Figure 12. Estimated Production from a 15,000 Tonne facility



Source: Author's estimate based on Legume Innovation Network (2021)

Clearly both the proposed oat milk facility and the ideas for the pea protein plant are at a national scale. As AbacusBio (2022) note this would mean that the facilities would effectively be shared. This has some advantages as smaller producers could benefit from the scale of the production and could simply supply a quantity that they are comfortable with. However, it could also have a number of disadvantages in terms of being able to control the supply chain. For example there may be issues around Intellectual Property and difficulties for individual suppliers in capturing the value generated in the chain.

The question emerges as to whether there is existing infrastructure that can be repurposed or whether constructing smaller dedicated facilities is viable. As an alternative, for oat milk we can look to the only existing processing plant in New Zealand, that servicing the Boring milk brand. The development of Boring oat milk and their relationship with the Apple Press company highlights that existing infrastructure (in this case used in the apple sector) can be modified. Although as noted there is not a complete overlap in the machinery required. As an aside within this supply chain, the oats are sourced from Southland and transported to the North Island for processing. There may be opportunities for more 'local' north island oat producers to access this chain.

Flour milling can be undertaken almost at any scale, from artisanal to industrial. In terms of existing industrial scale infrastructure, milling operations in New Zealand, like many other industries, have consolidated to a considerable extent. There are only four major millers, operating 5 mills, in New Zealand (Figure 13) and bar one, they are all overseas owned: Champion Flour Milling, Farmers Mill, MAURI, and NZ Flour Mills Ltd. PGG Wrightson Grain also offers milling services, however, they utilise the already mentioned mills.

Figure 13. Location and the representative organisation of each of mills in New Zealand

Source: NZFMA, 2021

It is not clear though the extent to which these mills would be available to process other products such as chestnuts, but again there may be the possibility to develop strategic alliances that are mutually beneficial, for example with the locally owned mill (Farmers Mill).

Our research has highlighted that for all the products it would be possible to establish plants to produce at a range of smaller scales and that there are various equipment suppliers available to do this.

Scale of Supply

The issue of infrastructure requirements is closely linked to the planned scale of production. In general, achieving sufficient scale and sales volumes is critical to generate sufficient gross margin to cover expenses, financial costs and investments. Major global producers such as Roquefort in protein extracts and Oatly in oat milk are producing on a very large scale and can benefit from potential economies of scale. Oatly for example, produced 300 million litres of oat milk in 2020, they procured about 300,000 tonnes of oats in one year; a figure more than tenfold the entire production in New Zealand.

As highlighted in the previous section, within a domestic context, there is limited processing infrastructure and to build it will be an expensive endeavour; as a result, options to support optimisation of manufacturing processes are limited (AbacusBio, 2022); the arable sector is small compared with Australia, Europe, or North America, and could constrain the ability to scale up production. In terms of scale it should be noted again that currently raw oats and dried peas are not high value crops and are often out-competed by other land-uses. Growing areas, and therefore annual yields, can be increased if the economic incentives are there for growers (PwC, 2022).

The concept of a viable scale of production has at least two dimensions, the first relates to being cost efficient enough to be competitive. The second is about generating sufficient product to service customer requirements, and linked to this is the need to provide sufficient returns to growers to motivate production.

As noted earlier, although based on a range of assumptions, both recent studies of the viability of pea protein extraction and oat milk plants suggest that plants on a national scale may be viable. This may provide a potential avenue for smaller producers to access the market. For example, investment in the processing facility could be made relative to the level of expected product delivered to the factory. The advantage would be that access is gained to a scale of production that is viable, that is, economies of scale may be achieved and also it may be possible to choose the level of supply that fits with the capabilities of the supplier. A possible disadvantage of such an approach is that the investment is in the processing plant and not necessarily the products that are made from the outputs of the plant. Therefore, there is the danger that the product becomes commoditised and the margins are squeezed– especially as we have highlighted the high levels of international competition emerging in these sectors.

Alternatively access to market may be achieved by investing in, or going into partnership with. an existing brand. Taking Boring milk as an example, it has already been noted that they source their oats from Southland which they process in the Hawkes bay. The potential to obtain supply more locally (subject of course to the suitability for growing oats) may be attractive to them whilst the partnership could allow the supplier to gain from brand. Again it may be possible to invest in line with the ability to supply.

Developing an own brand and/or building own processing infrastructure is possible but is likely to involve higher levels of investment and potentially significantly more risk. For milling or oat milk, smaller scale production seems more feasible than for protein extraction.

International Developments and implications for supply chains and farmers in New Zealand.

Internationally, it is possible to witness a number of trends in the alternative protein space. On the one hand we have rapidly increasing scale of production by 'specialist' alternative protein companies. As noted before, major global producers such as Roquefort in pea protein and Oatly in oat milk are producing on a very large scale and can benefit from potential economies of scale; Roquefort's facility in Canada is estimated to be able to produce 125,000 tonnes of pea protein a year

On the other hand there has been increasing interest in alternative proteins from the traditional dairy and meat sectors as they have witnessed the market grow. The move into alternative proteins by firms in these sectors is occurring in three main ways. They are 1) developing their own plant-based products (for example Wunda Pea drink by Nestlé) 2) engaging in joint ventures with other companies or 3) investing in start-ups and (for example Tyson foods investment in Beyond Meat). In addition, it is not necessarily a case of either animal or plant proteins as a number of companies are developing 'hybrid' products. For example Cargill is involved in a joint venture with Puris (a pea protein company) to produce burger patties that comprise both plant and meat protein and Purdue and Tyson have also developed 'hybrid' products

As well as eying market opportunities, it is argued that part of the strategy behind the shift for dairy and meat companies is to help meet targets for GHG emissions or carbon neutrality which may be hard to achieve without offsetting some of their production to more sustainable products. As noted earlier, emissions and other environmental impacts are generally significantly lower from alternative proteins. This strategy is clear from Nestlé who state that 'Through investing in initiatives to reduce the carbon footprint of dairy, launching more plant-based dairy alternatives, while exploring emerging technologies for animal-free dairy proteins, Nestlé will be able to transform its portfolio as a part of its broader commitment to provide food that's good for people and the planet.' (Nestle, 2022).

The symbiotic nature of the relationship between the established firms and start-up alternative protein businesses is described by one commentator 'Large meat producers have processing and distribution capabilities that start-ups need for keeping up with growing consumer demand. They also have established customer bases and marketing capabilities that can accelerate growth for these small companies (and their own companies) while minimizing their environmental impacts.'

Companies are not restricting themselves to only one possible manufacturing technique for new proteins. For example, as well as Beyond Meat, Tyson Foods have invested in Memphis Meat, Future Meat Technologies and Myco Technology. It has also been noted that the companies are not only developing consumer facing products but also developing new ingredients and raw materials to supply alternative protein products.

Within New Zealand, Fonterra has taken steps into non-dairy products, for example in 2019 it took a stake in Motif Ingredients, a US-based food ingredients company developing plant-based or cell-grown animal products, including milk. More recently it has announced that it is investing in a start-up company with Royal DSM to develop non-dairy proteins using precision fermentation. This approach from Fonterra, may well bring value to their farmer shareholders but will not lead to opportunities for NZ farmers as suppliers. Meanwhile, in 2021 a newspaper article[6] highlighted that Silver Fern Farms, the country's largest meat company, was in the early stages of exploring meat-plant hybrids as it looked to respond to customer demand. Within the article quotes attributed to their marketing manager provide insights into their approach. "One thing that will dictate our approach to these products is our core philosophy of natural ingredients and minimally processed products…We also need to navigate this space very carefully to avoid consumer confusion and potentially undermining the key proposition behind our other red meat products." Silver Fern's strategy would seem to open up opportunities for domestic supply of plant-based protein into these supply chains.

As with the multinational companies highlighted above, New Zealand companies have established sophisticated post farmgate supply chains for animal products both in the dairy and meat sectors which could also be utilised for plant proteins. Like their international counterparts these NZ companies could also benefit from the lower environmental footprint for alternative proteins to help reduce their overall emissions profile and improve their social license to operate.

Whilst diversification by mainstream livestock product companies can provide opportunities for NZ farmers and growers in the alternative protein space, there is still the question as to the extent that this will generate enhanced returns to producers. This relates to the extent that they

[6] https://www.stuff.co.nz/business/the-monitor/126948548/snail-farming-cricket-flour-algae-and-labgrown-fish-welcome-to-the-brave-new-world-of-alternative-protein

would be willing to pay a premium for NZ grown ingredients as opposed to those available in international markets which in turn will depend upon the extent that provenance is important for these companies.

Opportunities for New Zealand Growers?

As the market for alternatives to livestock and dairy products grows and there is scope for investment in production facilities to meet this growing demand, there would appear to be opportunities for NZ farmers to play a key part in the value chain.

In terms of oat production, AbacusBio (2022) explored a range of possible business structures which include collaboration around raw material production and/or processing and/or brand ownership. These structures are also relevant for the other crops under consideration in this study. In their study of the potential viability of a plant protein facility, PwC (2022) also considered various funding mechanisms including public-private partnerships.

At the most basic level, there could be opportunities for farmers to collaborate with each other to supply processing facilities with raw materials. The collaboration could take a range of forms from loose agreements to more formal business structures. Firms are likely to be keen to secure supply and if grower groups are able to commit to certain levels of supply over time then this may attract a premium. This premium however is likely to be limited though by availability of other supply both domestically and internationally. The more specialist the supply (i.e. the more skills that are required to grow the product) then the higher the premium is likely to be. The issue is whether the premium will be sufficient to encourage sufficient numbers of growers (or sufficient area) to move into the crops.

AbacusBio (2022) highlight the stark reality of the returns to farmers of simply supplying oats 'Oat supply is only a small part of the oats value chain that farmers represent currently (7 cents out of a retail price of $4.50), in part due to the large investment required in manufacturing. This highlights the need from a farmer returns perspective to have a larger investment in the value chain rather than remaining a supplier.' (AbacusBio, 2022)

Given the general lack of processing capacity identified for the crops under consideration, there would potentially be opportunities for growers to move down the supply chain by becoming involved at the processing stage. Again this may take a number of forms, either collectively across growers or some form of joint venture with international or national firms wishing to move into the area. In addition given the wider perceived benefits of creating strong alternative protein production systems in NZ, there may be the opportunity for public-private initiatives (PwC, 2022).

Whilst there is likely to be a margin in processing in addition to that in growing, access to this margin will likely require investment by growers. A key challenge is that due to the commoditisation of alternative proteins, manufacturers are unlikely to pay significantly above international market rates for NZ ingredients and if domestic production cannot attain the same economies of scale as elsewhere there is a real danger it will not be competitive. It is likely that partnerships are key to being able attain the overall capital required to achieve the scale necessary to establish a competitive industry. As discussed earlier these could be with traditional dairy and meat companies wishing to diversify or with international players in the alternative protein market. Either way it is likely that this will give NZ growers access to sophisticated marketing channels as well as an international customer base.

With models that involve simply growing or growing/processing, the key weakness outlined is really the inability to capture the margin that may be associated with a branded alternative protein product. For example, the AbacusBio (2022) study of the New Zealand Oat Milk value chain and its margins highlighted that a generic brand could be expected to operate at a relatively slim gross margin of 10 to 20 percent. They argue that to elevate products above the commodity level requires either a strong (brand) story (about the product, its attributes and its provenance), high levels of innovation (in novel products and uses), or developing value added products using the products as base ingredients. Each of these approaches has strengths and weaknesses. More generally Table 8 outlines some of the potential business models that could be adopted in New Zealand and some their strengths and weaknesses.

If value cannot be extracted from existing companies for growers, then it is important to consider the alternative options. There are international examples of models where, through their own initiative, farmers have been able to capture the value added in alternative proteins. An example of creating a unique selling point in the increasingly competitive alternative plant based sector is that of Glebe Farm Foods in the UK.[7] They have focused on producing and developing a market for *gluten free* oats made from their own oats. As well as producing their own oat milk product they also sell their oats to food manufacturers across the world on the

[7] https://www.glebefarmfoods.co.uk

basis of its gluten free status. Through investing in knowledge and on-site facilities the farmer has become a grower-producer and is able to derive greater margins from their products.[8]

Table 8. Possible Business Models

Business Models	Description	Possible Strengths	Possible Weaknesses
1) Grower Group	A range of business structures can supply processors under contract. Can supply either existing protein supply chains seeking to diversify or specialist alternative protein chains	It requires the least initial investment. A premium can be achieved through guaranteeing continuity and scale of supply Can encourage growers to expand	Hard to attain a significant premium against international prices Because there is no value-added process, the products would be traded as commodities.
2) Processing	Could invest as group of growers or through joint ventures with existing companies. Possibility of public-private investments	Moving further down the chain is likely to increase returns Can establish lasting business relationships with customers who require high-value ingredients	Significant investment needed in processing facilities Lack of scale may make it hard to compete with international producers. Even if can compete margins are unlikely to be high due to international competition
3) Differentiation	Could be achieved through branding, innovation of products, development of value-added products	Ability to capture more of final value of product through differentiation Ability to pass this back through the chain to growers	Significant challenges in developing new brand. Significant R&D costs for innovative strategy Increasingly competitive market may mean margins are eroded as new products and alternatives enter the market

[8] Source: https://corporate.proveg.com/wp-content/uploads/2022/06/Amplifying_Farmers_Voices_Report.pdf.

Conclusions

This study set out to provide an overview of the potential opportunities for alternative uses of existing crops in New Zealand. Three main crops were considered, Oats, Peas and Chestnuts and the derived products were found to compete in the alternative milk, alternative protein and gluten free markets

The alternative milk market is growing strongly worldwide; in the segment, oat milk has the fastest growth rate. Oat milk's market share is growing faster than soy and almond milk in America, Europe, Australia and New Zealand; consumer surveys indicate that oat milk flavour is a key factor in its success. As Oat milk is the growing star, most of the competitors and a significant number of incumbents in the alternative milks market are heavily investing in this segment.

The market for alternative proteins is also growing globally and is showing signs of maintaining this trend. Consumers in New Zealand and overseas are reducing their consumption of animal products and alternative-to-meat products are becoming increasingly visible throughout supermarkets and social media. There are a small number of New Zealand manufacturers entering the market by developing products using imported ingredients.

Among the three products, chestnut flour is less dynamic. Given that consumption has not motivated supply, the market is dormant. Most of the chestnuts are traded as fresh nuts, and not as a processed ingredient. A potential growth area for chestnuts lies in the growing Gluten Free (GF) market. Traditional ingredients in GF products are corn starch, rice flour, tapioca starch and potato flour; hence, including chestnut flour as the main ingredient could be a novel approach.

Oats and peas and chestnuts currently struggle against competing land-uses though they offer non-economic incentives for growers as they are a low-carbon, sustainable crop option. A higher price could encourage these crops to expand on existing systems in a large number of arable regions of New Zealand, offering improved soil health, and diversified land-use, cropping rotations (for peas and oats) and income streams for growers.

Chestnut growing in NZ occurs on only a few hundred hectares. Chestnut trees take five to seven years to start producing the first nuts, and their optimum production age is reached after fifteen years, therefore are a medium, even long term investment. As a fast-growing tree, chestnuts absorb and store significant amounts of carbon dioxide.

However, there is little oat milk processing capacity in NZ and no commercial plant protein extraction facilities. An oat milk plant of 60 million litres (with the capacity to increase to 80 million litres) is planned to open later in 2023. At average yields this would equate to a need for 1,800 hectares (2,400ha for an 80m litre plant). A plant of this scale would make the viability of smaller scale processing elsewhere in NZ is uncertain. Collaboration could enable access to larger scale plant for smaller producers. In terms of pea protein, a recent study has suggested that a 15,000 tonne plant could be viable within New Zealand. This would lead to the need for 4,300 hectares of peas to supply this plant.

Less is known about scale of chestnut flour processing. There are a number of flour mills located across NZ and it is assumed that arrangements could be made to utilise these. In addition milling can occur at a considerable range of scales from artisan to industrial.

Construction of processing plants at scale can provide opportunities for growers (either individually or probably more viably as groups) as demand will increase significantly. However, whilst there may be a margin based on security of supply and NZ provenance, this is unlikely to rise much above the cost of importing raw materials into NZ from competitor countries.

Growers can partner with international and/or national firms to enter the processing market. These partnerships can give NZ growers access to sophisticated marketing channels as well as an international customer base. Overall this may increase the returns to farmers, but again there are challenges in achieving sufficient scale to be competitive against international competition as customers are unlikely to pay significantly more than international market prices even if provenance can be guaranteed

The fundamental challenge though is returning sufficient value back through the chain to generate returns to growers that stimulate production as well as compensate for potential risks associated with investment further down the chain.

It is likely that NZ will struggle to compete with the main competitors in global markets who are taking advantage of economies of scale, so differentiation, product innovation, and (nation) branding are important to consider when positioning possible products from New Zealand.

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Appendix 1: Overview of New Zealand's main markets in terms of plant-based drinks and proteins

China

China is by far the largest destination for New Zealand products; a value over USD $11 billion in 2020, 28% of the total exports, gives an indication of the business scale. China is the world's biggest plant-based milk market. As China's population becomes wealthier, lactose-intolerant consumers are looking for dairy-free, protein-rich options (Austrade, 2022).

In 2020, China's plant-based drinks market was worth USD $11 billion (Chemlinked, 2021). This accounts for 24.2% of the entire beverage market (Austrade, 2022). According to Euromonitor (2020), the plant-based beverage market in China is expected to grow 2.7% per year on average from 2019 to 2024. Chinese supermarkets offer a wide range of options, principally from soy, followed by almond, oat, walnut, peanut, and coconut milk. Because of the dimension of Chinese market, the world largest food corporations are already running large operations and expanding their portfolios. Nestle, Danone and Pepsi, have launched oat milk products in the last three years (Mintel, 2021b).

Oatly, the most recognized oat milk brand, entered the Chinese market by forming a joint venture with its Chinese partner China Resources Corporation (Daxue, 2021). Oatly also multiplied collaborations with well stablished local tea brands and coffee shops to strengthen its' brand awareness. Nowadays Oatly is distributing its products all over China. There is growing interest among Australian companies in opportunities to sell plant-based protein food and beverages into China. Oppenheimer Pty Ltd, an Australia vegan food manufacturer and exporter, has set up a manufacturing facility in China (Austrade, 2022).

Domestic competitors are also very aware of these market trends. Chinese start-up Oakidoki raised USD $1.53 million in 2020 to expand their presence in the local oat milk market. Sales tripled three months after the firm made its product available in July. Oakidoki reported more than USD $15 million in yearly revenues by 2021 (Daxue, 2021). Other local companies are entering with aggressive pricing strategies. In December 2020, the Chinese dairy giant Yili announced the launch of two new oat milk and plant-based yoghurt products in 2021. This groups have clear advantages over foreign investors in the marketplace. They count on strong distribution channels both online and in retail stores.

Australia

Australia might be the second trading partner for NZ if sorted by dollars, USD $5,2 billion in 2020; but certainly, because of historical, political, social, and geographical dynamics, it is New Zealand’s most important partner.

Australian market dynamics for the plant-based beverages and proteins are among the most vibrant in the world, the market size is not as big as Chinese or American, but the growth is above 20% yearly (Hospitality, 2022). The plant-based milk market in Australia was worth USD $237 million in 2020 and increased to USD $352 m in 2021 (Hale, 2021). Plant-based milk may soon fill half of all drinks in Australian cafes as dairy alternatives skyrocket in popularity, with oat milk leading the charge.

Plant-based milk is on track to capture half of all Australian cafe drink sales. Oat milk is the fastest-growing plant drink in the market and might shortly be Australia’s most popular dairy alternative. Businesses are investing in processing infrastructure to make oat milk entirely in Australia. A study including more than 900 cafes found one in four Australians selected plant milk over dairy in 2021; the most popular choice was almond, followed by soy and oat. Plant milk is on track to capture half the cafe drinks market in the next few years, and oat could soon be Australia's top-selling dairy alternative, as previously reported, it has the strongest market-growth (Mackintosh, 2022).

Vitasoy, Oatly, Pure Harvest, Sanitarium, Macro, Califia, Just, Minor Figures, Chobani, Inside Out, Dirty Clean, Australians Own, and First Press are some of the most popular options for oat milk available in Australian supermarkets. A key difference between Australia and New Zealand oat milk is the vast availability of grains in Australia. Almost all the companies competing in the oat milk sector in Australia, are producing it there from locally grown oats, taking advantage of the economies of scale from the suppliers, and the close distance to retailers and consumers (Austrade, 2021).

USA

The United States are New Zealand's third trading partner; in 2020 NZ exports to America reach USD $4.4 billion (OEC, 2022). The U.S. is the worlds most important market for plant-based foods and drinks. Total U.S. retail plant-based food dollar sales grew three times faster than total food sales in 2021 to $7.4 billion (GFI, 2022).

As in 2020, the plant-based milk category in 2021 saw companies branch out from familiar plant-based milk products with a variety of novel products released, including ones aimed at directly matching the sensory properties of conventional milk instead of positioning around specific plant bases such as oat or almond. Danone pushed the envelope via new products from brands Silk and So Delicious. Chile-based NotCo, launched their plant-based NotMilk in the United States in late 2020, and the products are now available in Whole Foods Market stores. Danish vegan brand Naturli' launched Do Not! Call Me M_lk in early 2022 (GFI, 2022).

Retail product launches in 2021 came not only from dedicated plant-based companies but from large food companies, animal-based meat companies, and retailers. PepsiCo announced a joint venture with Beyond Meat to create a line of plant-based snacks and beverages for retail release in 2022. Nestlé, Switzerland; Pulmuone, South Korea; and Kerry, UK, launched multiple new plant-based food and beverages (GFI, 2022).

Table 9. Major competitors in the meat alternative segment in 2021. (Own elaboration with data from Euromonitor 2021)

Company	U.S. market share
Kellogg	18.5%
Beyond Meat	17.6%
Impossible Foods	16.7%
Maple Leaf	10.4%
Conagra	7.3%

Table 10. Major competitors in the plant-based drinks segment in 2021. (Own elaboration with data from Euromonitor 2021)

Company	U.S. market share
Danone	28.7%
Blue Diamond	24.8%
CEBA	4.7%
Califia Farms	3.5%
Earth's Own	3.0%

Japan & Korea

The plant-based milk market in Japan accounts for only 9% of the dairy market. Nonetheless, it's been growing steadily since 2019. In 2020, there was an acceleration, with food services like Dean and Deluca and Starbucks offering oat milk on a trial basis (Nishizawa, 2021). The market has been focused on soybeans for many years. The leading manufacturers: are Kikkoman and Marusan, with market shares of 50% and 20%, respectively. Since 2013, the almond milk market has seen double-digit growth in sales. While still a relatively minor segment, almond milk has visibly made its way onto soy-dominated shelves and is nicknamed the "third milk" after dairy and soy milk (Nishizawa, 2021). In this segment, one player dominates the market: Ezaki Glico group holds 90% of the market share (True Data JP, 2021).

Soy and almond milk are not the only alternatives on the Japanese market. Kikkoman launched macadamia milk in 2020. Rice, sesame, barley and nut-based milk are also available, but competition for market share is very intense (Nishizawa, 2021). Oat milk arrived in Japan in 2018 with Provamel, EcoMil and The Bridge. Oat milk took centre stage when Danone Japan launched Alpro in April 2020 (Ibid). Oatly entered the market in 2021; Marusan, a Japanese soy and almond milk manufacturer, launched the first locally produced oat milk in Japan that same year; Dolher, a German company, launched its OATme brand in early 2022 (Ibid). As in all other markets, oat milk is expected to overtake almond milk in the coming years.

The growth rate of the non-dairy plant-based milk market in South Korea is higher than that of the dairy milk market (Korea Dairy Committee, 2021). In Korea, although the plant-based non-dairy dairy industry is currently in its infancy, many food companies that produce beverages have launched or are preparing plant-based non-dairy milk substitutes. The size of the non-dairy plant-based milk substitute market in Korea is growing at a rapid rate of more than five times from about USD $64 million in 2016 to about USD $331 million in 2020 and is expected to increase to $500 m by 2025 (Euromonitor, 2021).

The main plant-based drink in South Korea is soy milk. However, consumers have recently moved away from soy and a variety of plant-based milk substitutes are slowly being launched: Maeil Dairy launched Almond Breeze in 2015 as an alternative to dairy-based dairy products for consumers with milk allergies and vegetarians; Coca-Cola produces and markets a 'Georgia Craft Decaffeinated Oat Latte' with oats; Starbucks is already rolling out an oat milk alternative to milk, and the 'Amazing Oat' product will be available daily in the second half of 2021 (Kim et. al., 2021).