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ALTERNATIVE PROTEINS AS PART OF FUTURE FARMING: THE CLAIMS AND THE REALITY

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Background

Hyped-up data free media headlines are part of modern-day living. The internet allows articles to be posted and if the headline doesn't turn out to be clickbait, it is easy to reword and repost… until the hits, likes and shares escalate.

Stories about the damage that animals are thought to do to the environment and suggestions that becoming vegan will save the planet have appeared in the media with increasing frequency. Last November, Dr Helen Darling's opinion column in the Herald (21st November 2021) appeared with the headline Is NZ ready for the plant-based meat revolution? It was subtitled 'Are NZ's primary producers preparing for a change?'

Taken together, it isn't surprising (a) that farmers are feeling confused about what they should do and (b) national and local government have been pushing for a change.

In the Waikato, for instance, the Regional Council (via a report from AgFirst 2016) has suggested that dairy, sheep and beef land uses would be more profitable (and with lower environmental externalities) under dairy goats, dairy sheep, gold or green kiwifruit, apples or chestnuts. The practical and financial capacity details aside, of these options only those with 'dairy' (goats or sheep) create protein of high quality. Further, the plant-based alternative requires cropping land, with flattish topography, dry conditions at harvest and appropriate growing degree days - amounting to less than 200,000 ha of New Zealand. Synthesised/cultured protein has similar problems in practical and financial requirements

This paper is written for rural professionals to assist with farmer morale and give some of the information required to explain to urban people convinced that veganism is the new future, that not even the vegans would be better off.

Importance of protein and dietary choices

Intuitively most people recognize that animal-based food is a natural part of a human diet. We have incisors, canines and molars to deal with a variety of foods. Research has shown that access to animal food allowed evolution of our unusually large & complex brain, and enabled us to be large, active and highly social primates (Milton 2003). However, the ongoing statements that plant protein is just as good (e.g., de Boo & Knight 2020) is eroding that understanding. In addition, statements from high profile activists that we must become vegan to stop climate change and save the planet is having an effect – people are changing their diets. That effect is not, however, as big as some would have you believe.

The research around diet is self-reporting and although vegan groups suggest that "As many as 6% of U.S. consumers say they are vegan — a 6x (500%) increase compared to just 1% in 2014"… the range of estimates in the same article is 2-6%. Later it is stated that the number of vegans in the US has increased by 600% since 2014 (Djurovic 2021). Exaggeration leads to confusion; journalists can pick on whichever figure they like, point to the source and be right.

New Zealand is not immune and in 2019 a rash of headlines, including 'why 33% of New Zealanders are ditching meat' was based on a report for Food Frontier, an independent thinktank on alternative proteins. Just over 1000 people were surveyed and the report indicates 31% of people were flexitarian ('eating what they want when they want) or 'Meat Reducers'. A further 3% were vegetarian or vegan.

Research in 2018, surveyed more than 47,000 New Zealanders and found that approximately 94% still ate meat and under 6% were vegetarian or vegan. Longitudinal analyses further revealed that the probability of shifting from an omnivore diet to a vegetarian or vegan diet over a one-year period was low (less than 0.6% changed to vegan and just under 1% became vegetarian). In contrast, almost 30% of vegans changed diet between 2017 and 2018, with slightly more becoming omnivores than vegetarians (Milfont *et al*. 2021). Of people following a vegetarian diet in 2017, 22% changed diet in the following year, with an 8:1 ratio of a change to omnivore rather than vegan. Vegans were considered to be the least stable category. The difficulty of committing to dietary change is not restricted to New Zealand. In the UK the annual diet survey reported that 'of the 5.2 million that hoped to completely cut out meat by the end of 2019, only 5% (236,000) had done so'. (https://www.finder.com/uk/uk-diet-trends). In 2022, 8.8 million people across the UK plan to become vegetarian, vegan or pescatarian, but last year only 2% of the 6.5 million people who had declared their intention for 2021 actually did so.

Plant-based and cultured protein

Whatever the preference for diet, farmers in New Zealand, unbuffered by subsidies since the mid-1980s, have always reacted to market opportunities. In some areas with cropping infrastructure, e.g., Wairarapa, Manawatu-Whanganui, Canterbury and Southland, crops including hemp, quinoa, and oats are being grown and considered for new uses such as 'plant-based milk' and 'plant-based protein'. This is despite a change in land use from pasture to cropping is associated with a decrease in soil organic matter (e.g., Curtin *et al*. 2020), thereby contributing more carbon dioxide to the atmosphere. It also overlooks the fact that although methane from ruminants is avoided, increased use of agrichemicals and of fossil fuel has the potential to create longer term impact than that of ruminants. The farmer decision is usually based on returns, which are becoming increasingly constrained within regulations and environmental taxes.

Vat fermentation for culturing protein has been proposed as the biggest threat to ruminant farmers, with its claims of vastly reduced environmental impact. However, like 'plant-based proteins' most of the claims are hype. Analysis by non-profit investor network Ceres (Ceres.org 2021) has shown that the claims made, whether by plant-based or fermentation companies, are based on the environmental impact of the company alone, not a complete life cycle analysis which would include the supply chain and waste. All the alternative protein companies rely on crops, either for the substrate of their processing (e.g., potatoes, rice, pumpkin, pea isolate) or the energy to drive the fermentation (usually corn syrup or sugar cane). Consequently, all plant-based 'alternative proteins' require land upon which to grow the component crops, and crops require agrichemicals – fertilisers and compounds to suppress weeds, pests and diseases. They also require fossil fuel to drive tractors, harvesters and for basic processing.

'Meat'

Beyond Meat, which describes its products as "plant-based, vegan meat that's tasty and better for you and our planet", discloses nothing. Impossible Foods, claims that eating the Impossible Burger will reduce your environmental footprint through reduced water (87%), land (96%) and lower greenhouse gas (GHG) emissions (89%) in comparison with a bovine burger. The figures are not supported with data.

The Ceres 2018 report 'Measure the Chain: Tools for Assessing GHG Emissions in Agricultural Supply Chains' estimated that over 80% of the emissions generated by food systems stem directly from agricultural production and its associated land-use change. Most food and agricultural companies, consider these emissions to be "scope 3". They are upstream

or downstream emissions not under direct control of the company (i.e., indirect emissions) and so are not included in their impact and 'savings' statements.
Similarly, global ESG (Environmental, Social and Governance) company Sustainalytics suggests that plant-based products appear to solve the methane problem from ruminants but create other problems. Most contain soy, for instance, which is linked to deforestation and genetic engineering.
Cultured meat presents itself similarly. Memphis Meats (upsidefoods.com) states that is making meat in a new way: "One that satisfies our cravings, our conscience, and our heart." Memphis meats is still at the pilot stage but claims (through investor Richard Branson) that cultured meat will use much less water, land and produce up to 90% fewer GHG than conventionally produced meat. No data are available to indicate how and questions are being asked (e.g., Chriki & Hocquette 2020).
The problems of scaling up cultured meat have been examined by the Good Food Institute. Meeting 10% of the world's meat demand, estimated at 40m metric tonnes by 2030, would require 4000 factories each costing around €382 million and housing 130 x 10,000L stirred tank bioreactors, each of which would be associated with 4 x 2,000L perfusion tanks. Each factory would need to be able to host 2,300,000L cell culture. The current largest facility hosts 250,000-350,000L cell culture (Vergeer *et al*. 2021).
The energy costs of maintaining a controlled environment are considerable, the embodied energy costs in creating large vats for fermentation are significant, and the energy for the fermentation has to be provided by something – sugar is the cheapest option, and sugar, whether from maize, cane or beet, is a crop, requiring the agrichemicals and fossil fuel already mentioned.
The impact of all the overlooked factors could last very much longer in the atmosphere than the methane from ruminants, the effect of which has gone in a few decades.
University of Oxford physicists have suggested that "under continuous high global consumption, cultured meat results in less warming than cattle initially, but this gap narrows in the long term and in some cases cattle production causes far less warming, as methane emissions do not accumulate, unlike carbon dioxide" (Lynch & Pierrehumbert 2019). The authors identified a need for detailed and transparent life cycle analysis (LCA) of real cultured meat production systems and concluded that the relative impact of cultured meat will depend on the availability of decarbonized energy generation and the specific production systems that are developed.

'Milk'
Milk from dairy animals contains nutrients and processing is required to ensure human safety and product stability. Most of the plant-based alternatives contain additives to boost their nutrient content and stabilisers to prevent the additives from settling out.
Perfect Day (called Muufri in 2014) has given up on creating milk through vat fermentation and is now trying to perfect 'dairy' ingredients. Success has been achieved using genetically engineered fungi to produce milk protein for ice cream. Other companies (TurtleTree and Better Milk) are in the early stages of engineering mammary cells from humans and cows. This approach has similarities to cell-based meat and is likely to meet the same acceptance challenges identified by Pakseresht *et al*. (2022).

Bio-availability and anti-nutritional factors
In the plant-based protein cases, essential amino acids (particularly lysine, leucine and choline) or EAA for human nutrition are in poor supply. Milk has a Protein-Digestibility-Corrected-Amino- Acid-Score (PDCAAS) value of 1, which indicates that all the protein (3.7g in 100g) is nutritionally available. Beef has a PDCAAS of approximately 0.92 whereby 100g raw steak

contains18.4g usable protein. Quinoa is 0.85 and so 100g (dry) contains 11.9g usable protein. Rolled oats have a PDCAAS of 0.57 so 100g (dry) contain 9.6g usable protein.
Of further note is the anti-nutritional factors in plants, evolved to protect their proteins from animal predation. To overcome the protection barriers, humans apply external treatments such as fractionation, soaking, heating, acidification, fermentation and pulverisation. Treatment takes time and energy, and causes losses, which increases the greenhouse gas emissions associated with the food. Soybeans, for instance, which are generally considered to be the best large-scale plant-protein source, have high concentrations of dietary trypsin inhibitors, oestrogen mimics and tannins. The result is that only a portion of the soybean protein is digestible; the estimate is approximately 73% in comparison with 80- 100% from animal proteins.
Although plants-only agriculture has been modelled for the US to produce 23% more food, as suggested in the previous paragraph, it met fewer of the US population's requirements for essential nutrients. When nutritional adequacy was evaluated by using least-cost diets produced from foods available, more nutrient deficiencies, a greater excess of energy, and a need to consume a greater amount of food solids were encountered in plants-only diets (White & Hall 2017).
Animal-derived foods meet essential amino acid needs up to 240% more effectively than plant-derived foods (Dr Graeme Coles, Nutrition Scientist, Pers. Comm. 2021). This means that vegans excrete far more excess N (possibly as much as 140%) than carnivores, all of which is at some point oxidised to nitrous oxide, a GHG, in the atmosphere. Vegans also require more land and calories to meet their EAA needs, and supplements which are not included in environmental impact of diet calculations. In a modelling study on 'people fed' from the Canterbury Plains, Coles *et al*. (2016) concluded that mixed dairy/cropping systems provided the greatest quantity of high-quality protein per unit price to the consumer, had the highest food energy production and supported the dietary requirements of the highest number of people, when assessed as all-year-round production systems.

Miscalculation, misrepresentation and misunderstanding
The claims that plant-based diets are environmentally better than omnivorous diets are based on various pieces of research, most of which have been challenged and some of which have been discredited.
The FAO 2006 document 'Livestock's Long Shadow' (Steinfeld *et al*. 2006) has had global impact. The document stated that livestock agriculture produced 18% of global emissions, and that 'Livestock was doing more to harm the climate than all modes of transportation combined'. The analysis used a complete life cycle for meat (emissions from fertiliser production, converting land from forests to pastures, growing feed, and direct emissions from animals (eructation and manure) from birth to death) and compared the result with an incomplete assessment of transport - the emissions were calculated on exhaust from vehicles.
More recent research from the FAO (Mottet *et al*. 2017) showed that grazing livestock contribute directly to global food security by producing a greater amount of highly valuable nutrients for humans, such as high-quality proteins, than they consume. Dr Mottet's research indicates that somewhere between 7 and 13% of beef production comes from feed lot systems, yet most of the concerns about GHG are based on this small percentage.
Of further interest, the authors state that 'out of the 2.5 billion ha needed for animal production, 77% are grasslands, with a large share of pastures that could not be converted to croplands and could therefore be used only for grazing animals'. (Note that these grasslands in New Zealand support considerable soil carbon stocks and biodiversity – not as much of the latter as native forests, but certainly more of both than arable areas where soil disturbance is part of

production.) Note also that arable land can be used to produce grazeable biomass between crops, and during fallow periods needed to restore soil structure – indicating a role for animals. Also important is the leather, wool, tallow, sinews and other by-products that come from animals (Mottet *et al*. 2019). Leather shoes or wool suits can be replaced with those made from materials such as cotton, linen, bamboo or wood (lyocell) but that means more land under cultivation, and processing bamboo (or wood) into something that can be worn next to the skin requires a chemical and energy-heavy process. These products could be made from 'synthetic' materials but this usually involve the petroleum industry. The GHG implications of the replacements for materials other than food and by products that traditionally come from animals are not usually included in dietary calculations.

Greenpeace International recommended in 2018 that diets should be reconsidered for both human health and the environment. Reductions in meat and dairy consumption were recommended, not a complete removal of animal products from the diet. The take home message was that land which could be used for growing food for direct human consumption should be, with animal products coming from land that wasn't suitable for anything but pasture (Greenpeace 2018). No full life cycle analysis was provided to support this assertion.

The 2019 IPCC reports did not advocate becoming vegan. It stated that "Balanced diets, featuring plant-based foods, such as those based on coarse grains, sustainable legumes, fruits and vegetables, nuts and seeds, and animal-sourced food in resilient, sustainable and low GHG emission systems, present major opportunities for adaptation and mitigation while generating significant co-benefits in terms of human health". Even so, position papers such as the 'Save the Planet' diet proposed by the EAT-Lancet Commission (Willett *et al*. 2019) have continued to be promoted but failed to recognise population health realities. Plant-based diets require consumers to eat a significantly greater amount of dietary energy than is good for health (White & Hall 2017), to obtain enough of all other nutrients. Only an animal-based diet can solve this problem.

The Future

Nutrition company Cargill's March 2019 Survey 'Feed4Thought' (Sullivan 2019) found that more than two thirds of people surveyed in four different countries intended to maintain or increase their consumption of animal protein this year.

Although 80% were interested in exploring plant-based or alternative sources of protein, they weren't intending to drop the animal component of their diet. In addition, 93% of them considered animal protein was an important part of a healthy (and delicious) diet, and 80% of them believed that animal protein could be part of an environmentally friendly diet. The facts allow them to do so with a clear conscience and the dietary data (Milfont *et al*. 2021) indicate that omnivores are prevalent. Further, reports suggesting that 'appetite for plant-based meat has already peaked (e.g., Financial Times at the end of January) indicate that consumers have been seeking variety by incorporating new products into their diets, rather than the lifestyle switch that has been hyped.

New Zealand pastoral farming produces animal protein (meat and milk) for fewer GHG emissions per unit of protein than other countries currently manage (Payen *et al*. 2020, Mazetto *et al*. 2021). The Paris Climate Agreement emphasised decreasing GHG without compromising food production. Poorer performance in other countries affects us through, for instance, temperature and sea level rises. New Zealand is part of the physical, chemical and biological globe and cannot isolate itself through policy.

Calculating land use and environmental impacts based on essential amino acids would create a different picture for New Zealand (e.g., Coles *et al*. 2016). A full life cycle analysis of proposed alternative food production systems would create a different outcome from that espoused. Ongoing research in precision agriculture, which includes targeting inputs and managing soil

organic matter, will support good farmers into the future. Adaptive strategies are in their DNA. So is identifying bullshit – sorting the claims from the reality…

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