The seaweed opportunity

High value-added and customised food products in Singapore

Southeast Asia
Centre of Asia-Pacific Excellence

Executive summary

New Zealand and Singapore have enjoyed diplomatic relations since 1965 and have collaborated in areas from digital protocol to trade. This report considers how issues such as the food crisis, climate change, the COVID-19 pandemic and changing consumer trends have created the opportunity for New Zealand to export seaweed-based products to Singapore. We identify three potential seaweed products, based on a number of government publications, industry reports, and peer-reviewed literature. The products could be used as a seasoning for food, a health supplement, and an alternative protein.

The COVID-19 pandemic has had a large, positive effect on consumer preferences for nutritional products. As a result, consumers have become increasingly attracted to food and beverage products that offer health and nutrition benefits. Consumers in Singapore are choosing healthier diets (e.g., plant-based, keto) and are increasingly interested in supplements that target pain or boost energy (NZTE, 2022).

Dried seaweed contains minerals, vitamins, and other bioactive compounds that make it an attractive functional food for Singaporean consumers. Methods for drying seaweed and extracting nutritional components are widely available, and much research has focused on the bioavailability and health benefits of key compounds. Highlighting the nutritional benefits of seaweed products is a key part of the marketing strategy for this product.

Currently, there is no supply chain for farmed seaweed in New Zealand. Existing seaweed-based enterprises harvest wild seaweed from New Zealand shores or import farmed seaweed from Asia. Government-funded initiatives are currently researching the viability of commercialising seaweed farming in New Zealand, and if successful, this could open a new aquaculture sector that has benefits for both the environment and local economy.

The worldwide agrifood value chain is under immense stress from demographic challenges, trade conflicts, and environmental change. These changes have spurred innovation in Singapore to move the country toward self-sufficient food production. Singapore is a favourable country to develop and commercialise a high value seaweed product, because it has comprehensive food R&D facilities, shared infrastructure, a favourable food regulatory environment, a vibrant and globally connected innovation ecosystem, and strong investor and corporate interests.

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Introduction and background

The New Zealand – Singapore trade relationship

New Zealand and Singapore have had a diplomatic relationship for over 55 years, based on common interests and shared history (MFAT, 2019). Many New Zealand businesses use Singapore as a base to operate throughout ASEAN (Association of South East Asian Nations), and Singapore is New Zealand's seventh largest trading partner and an important source of investment (New Zealand Ministry of Foreign Affairs and Trade, 2019).

In 2018, the total trade in goods between New Zealand and Singapore was NZ$3.32 billion (S$2.84 billion), with exports to Singapore totalling NZ$1.26 billion (S$1.08 billion). New Zealand's main exports to Singapore are dairy, oil, animal fats, food preparations, and wood. Imports from Singapore to New Zealand total NZ$2.06 billion (S$1.76 billion), including oil, food preparations, tobacco, plastics, and machinery (MFAT, 2019).

New Zealand and Singapore are parties to various regional and free-trade agreements that help to facilitate business ventures, including:

- NZ–Singapore Closer Economic Partnership
- Comprehensive and Progressive Trans-Pacific Partnership (CPTPP)
- ASEAN–Australia–New Zealand Free Trade Agreement (AANZFTA)
- Trans-Pacific Strategic Economic Partnership (P4)
- Regional Comprehensive Economic Partnership (RCEP)

The fact that in 2022 Prime Minister Jacinda Ardern's first overseas trip in more than two years began in Singapore is a testament to the importance of Singapore's trading relationship with New Zealand.

Benefits of seaweed food products

Since prehistoric times, seaweed has been a staple food in many Asian countries, including Japan, Korea, and China, as well as in parts of Europe. The food is valued for its nutritional benefits and its unique taste and texture.

With a global focus on functional foods, seaweed is being rediscovered for its bioactive properties that can have positive effects on the human body (Choudhary, Chauhan & Mishra, 2021). Bioactive compounds in seaweed include polysaccharides, polyphenols, phytochemicals, and polyunsaturated fatty acids. Seaweed is also recognised as a good source of dietary fibre, proteins, minerals, and vitamins. Commonly praised as an excellent source of iodine, seaweed also has high amounts of vitamins A, D, E, C, and B and minerals such as calcium, magnesium, iron, and potassium (Choudhary, Chauhan & Mishra, 2021).

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Seaweed farming potential in New Zealand

Currently, seaweed processing companies in New Zealand rely on washed-up seaweed around the coastline or imported seaweed. AgriSea produces agricultural and horticultural products such as fertilisers, animal supplements, and other functional products from wild gathered seaweed. Pacific Harvest sells seaweed seasonings, powders, flakes, and salts from wild dried seaweed and farmed seaweed imported from China (Pacific Harvest, 2022).

A three-year, NZ$5 million (S$4.28 million) regenerative ocean farming pilot, funded by the New Zealand government and Auckland City Council, is set to commence in 2023 (New Zealand Ministry for Primary Industries, 2021). This research will be conducted in collaboration with Māori entities, so that it closely aligns with Māori values and upholds the relationship Māori have with the sea. The scope of this pilot will include investigating the market opportunities for seaweed products both in New Zealand and globally, as well as working on post-harvest processing logistics and product development.

GreenWave NZ, a non-profit organisation adapted from GreenWave US, has been set up to promote sustainable ocean farming and provide support for Kiwi farmers who want to tap into the economic benefits of building a seaweed supply chain. Unlike traditional intensive land crops, seaweed farms have the potential to improve the environment and promote climate resilience.

A government-funded project by the Cawthron Institute investigated the suitability of using a native red seaweed (*Asparagopsis armata*) in animal feed to reduce agricultural methane emissions (New Zealand Ministry for Primary Industries, 2019).

The project highlighted further commercial prospects for seaweed farming in New Zealand beyond food applications.

Successful seaweed farming methods in New Zealand could be developed by adapting known aquaculture processes developed by large exporters in China, Indonesia, and the Philippines. These could be combined with current practices used on local oyster and mussel farms.

Seaweed species

Seaweed is categorised into three distinct groups based on colour: green seaweed, brown seaweed, and red seaweed. A report by the New Zealand National Science Challenge has identified six seaweed species in New Zealand (out of approximately 850 native species) that have commercial potential (Wheeler et. Al., 2021). Table 1 lists these six species and how they could be used. Research and development carried out under the pilot scheme will start with brown kelp (*Ecklonia radiata*) and assess its suitability for commercialisation.

Table 1: Six species of NZ native seaweed and potential uses

Seaweed type	Potential usage
Karengo	Food source that is high in protein, vitamin B12, and omega-3 fatty acids and is a taonga species.
Asparagopsis	Cultivated for use in cosmetic products and can reduce methane emissions when used as a feed supplement.
Agarophytes	Used for food and agar, but it might be hard to compete with other countries that produce agar.
Lamanarians	Includes bladder kelp and wakame, which is invasive but can be grown using long-line cultivation.
Fucoids	Sold as food or food ingredients.
Green algae	Used to produce biostimulants and fertilisers.

Proposed high value food products

Given that there is currently no established supply chain for New Zealand farmed seaweed and seaweed products, we suggest three high-value seaweed product concepts and provide details on production processes, capacity, product attributes, as well as core, intangible, and augmented product benefits.

1. Seaweed seasoning

Many existing seaweed products use dried, ground seaweed. Drying can remove up to around 85% of the weight of the seaweed, which allows it to be processed into a powder of variable roughness. Drying must be controlled, however, as excessive moisture removal can reduce the bioactivity of the compounds. Small quantities of alcohol may be used to remove some of the crunchiness and fishy flavour from the seaweed, to make the end products more palatable.

Mixing this with other seasoning ingredients can help create flavour and texture while retaining the unique taste of seaweed. Dried seaweed contains minerals, vitamins, and other bioactive compounds, though some compounds lose their bioactive properties when certain extraction processes are used.

2. Seaweed supplements

The extraction and purification of components from seaweed is a complicated process. The methods must be targeted to specific components, as the method will determine both the yield and bioavailability of the extract.

The process of creating a seaweed product typically includes a cleaning and drying stage with an acid wash, followed by physical processing. This physical processing applies heat and pressure to the product. A fermentation process can also be used to break down seaweed cells.

Organic solvents and enzymatic methods can be used to extract components such as proteins and pigments. The degradation of proteins and polysaccharides can create bioavailability and promote absorption.

Chemical hydrolysis is a common method for seaweed extraction, which can reduce bioavailability but is cost-effective. The diversity in seaweed extracts available commercially can be attributed to differences in manufacturing methods.

The compounds in a seaweed extract product will ideally contain plenty of bioactive carbohydrates, proteins, pigments, and other trace elements.

3. Seaweed in alternative proteins

Singapore is at the forefront of cellular agriculture, and it was the first country in the world to commercially approved lab-made chicken products. The high-carbon footprint of producing animal protein, paired with the increasing world population and climate change, has created a need to explore alternative protein options. Cellular agriculture involves growing animal tissue from animal cells on a “scaffold” by feeding them a nutrient serum in a controlled environment (Ogilvie, 2021). Considerably fewer natural resources are required to produce this form of protein.

Seaweed can be used to provide structure, texture, and/or umami flavour to both plant-based and lab-grown meat products. Some red seaweed varieties contain up to 47% protein on a dry weight basis (Thiviya et al, 2022). Seaweed itself can also be used as an alternative protein source, and research suggests that the red colour and savoury flavour provide an edge over typical plant-based protein ingredients such as soybeans and peas.

Vitamin B12 deficiencies are often prevalent among vegetarian and vegan consumers, as this essential vitamin is naturally present in foods of animal origin and is often deficient in plant-based alternatives. There is still some speculation as to whether seaweeds are a reliable source of vitamin B12, so further research is required to determine its bioavailability.

Barriers to adoption

One of the main challenges to the adoption of seaweed in food products (particularly in alternative proteins) is the distinct taste and odour of seaweed. Fortunately, this is more of a concern for the Western palette and less problematic for Asian consumers, who are often more familiar with the characteristics and uses of seaweed.

Another potential barrier is competition with existing seaweed producers, who can produce much larger volumes of seaweed at much lower prices.
New Zealand farmed seaweed will not be able to compete on volume (and thus cost). Therefore, it may be more worthwhile to leverage the uniqueness of New Zealand native species and market them at a premium to consumers.

Market potential

Seaweed aquaculture's untapped potential

Seaweed aquaculture is the world's fastest growing food sector (Agri-Food Tech Expo, 2020) and primary industry (LEARNZ, 2022). New Zealand alone has 850 species of native seaweed with a third of these not found anywhere else in the world (LEARNZ, 2022). While Asia currently accounts for 99% of the world's seaweed production (Holmyard, 2020), New Zealand (along with the rest of the world) is beginning to realise the untapped potential of seaweed aquaculture. With the NZ$5 million (S$4.28 million) commercial regenerative seaweed farming pilot, New Zealand government agencies and councils are pushing to help establish and encourage national seaweed farming (New Zealand Ministry for Primary Industries, 2021).

Seaweed aquaculture presents a number of commercialisation opportunities for alternative proteins, fertiliser, cosmetics, pharmaceuticals, nutraceuticals, textiles, pigments, plastics, and construction materials (Agri-Food Tech Expo, 2020). As a side benefit, seaweed aquaculture provides many environmental benefits. Seaweed varieties grow ubiquitously in the ocean and therefore do not require soil or freshwater to grow, both of which are in increasingly short supply. Seaweed does not require fertiliser (which is often harmful to marine ecosystems) as it absorbs nutrients from water and other sea life. In addition, seaweed takes up carbon dioxide through photosynthesis, offering potential for decarbonisation of several industries. Not only can seaweed help clean up agricultural wastewater run-off (bioremediation), it also can be grown as part of a polyculture (grown with other sea life). These benefits suggest seaweed aquaculture could be highly sustainable.

Moreover, seaweed farms provide a habitat for marine life, predicted to increase biodiversity by 40% and species abundance by 30% (TNC, 2021). Seaweed can also act as a living breakwater, helping to mitigate future flooding risk as ocean levels rise (Agri-Food Tech Expo, 2020). Lastly, seaweed farming provides income to many families in rural communities within the Asia-Pacific region.

Agrifood overview

Increasing global demand and resource/environmental constraints have put immense strain on the agrifood value chain (Enterprise Singapore, 2022).

These include the following factors:

- **Demographic Challenges**
  There is projected to be a 26% increase in the world's population from 7.7 billion (2019) to 9.7 billion (2050), with 68% of the population projected to live in cities.
- **Consumer Preferences**
  There is an increased awareness around sustainable production and food safety, with rising protein consumption in developing countries.
- **Environmental Degradation**
  There is a growing incidence of crop failure and supply chain shocks due to climate volatility, with 70% of the world's fish species fully exploited or depleted, and 33% of the world's arable land degraded.
- **Trade Conflicts**
  Protectionist tendencies and trade wars have necessitated the shoring up of domestic agrifood production.

Agrifood Singapore

Singapore imports 90% of its food and is susceptible to climate change and geopolitical uncertainties. The government is working toward being self-sustainable, and it is diversifying its food supply sources to increase food security (NZTE, 2022). It has developed a "30 by 30" goal to have 30% of food grown in Singapore by 2030.

This strategy means there is increased investment in high-tech farming infrastructure, research and development in food technology, and production. Local farmers have increased support to expand their production capacity, raise productivity, and boost yield. There is also a national emphasis on healthier eating with more low sugar options and nutritional labelling, creating a great market entry opportunity for New Zealand food and beverage businesses (NZTE, 2022).

Growth in aquaculture and alternative proteins

The modern aquaculture market is expected to grow with a 4.7% Compound Annual Growth Rate (CAGR) from S$178 billion (NZ$208 billion) in 2017 to S$363 billion (NZ$424.4 billion) by 2025 (Enterprise Singapore, 2022). Plant-based proteins are also expected to grow with a CAGR of 28%, from S$6 billion (NZ$7.1 billion) in 2018 to S$112 billion (NZ$130.9 billion) in 2030 (Enterprise Singapore, 2022). The seaweed resource is fundamental in both markets.

The Singapore food story

Singapore is a highly productive and resource efficient agri-tech hub that prides itself on its safe, sustainable and high-quality produce. Singapore is a preferred test-bed for innovative agri-tech solutions and products for the ASEAN and East Asia region, as well as for the rest of the world. Singapore also has a socially oriented agriculture community with strong consumer connection and trust (Enterprise Singapore, 2022).

Demand for seaweed health products

Research in Australia suggests that early adopters of seaweed food products tend to have higher education levels, be adventurous in their food choices, and perceive seaweed consumption to have symbolic value. They are also health conscious "snackers" (Birch, Skallerud & Nicolas, 2018).

Research from China indicates that families with a food-decision maker who has a job will consume more seaweed. It also attributes the increase in seaweed consumed away from home to its growing use in fast food, which saves time (Food Navigator China, 2022).

The Asia-Pacific region has dominated the seaweed snacks market with a share of more than 50% in 2019. This is attributable to the availability of the product in different flavours and textures, along with its popularity as a topping for kimbap and other Korean rice meals. Moreover, the increasing adoption of veganism has fuelled product demand, because seaweed is an excellent source of iodine, which is mainly found in animal proteins such as fish, chicken, eggs, and dairy (Harvard T.H. Chan School of Public Health, 2022).

Brown seaweeds are increasingly preferred in prepared snacks because of increasing awareness of their health benefits. Brown seaweeds include some of the largest sea plants and are known for their high iodine content.

The rich nutrition profile of seaweed products is attractive to consumers seeking a healthier diet. Such products fit well with the rising trend of "free-from" food products (i.e., products free from common allergens, gluten, and GMOs; Grand View Research, 2019). In recent years, increasing health awareness has spurred Singaporeans to buy more non-processed 'natural' foods, vitamins, and supplements.

Sales of food categorised as 'better for you' (with reduced fat, sugar, and/or salt) are becoming more popular, as are products that promote gut health (reflected in the high growth of yoghurts and probiotics). Companies are also highlighting products' nutritional benefits on packaging.

Singapore's consumers are increasingly opting for herbal and traditional dietary supplements that contain natural and organic ingredients. They often have a good understanding of the ingredients in supplements. Products such as co-enzyme Q10, collagen, and folic acid are popular (NZTE, 2021).

The COVID-19 pandemic has also had a significant impact on consumer demand for nutritional products, by magnifying consumers' demand for health products and functional foods. This demand is driven by the belief that some of these products can act as a prophylactic for COVID-19 by improving consumers' immune systems (Lordan, 2021). The added demand supports the already high-growth market segment of functional foods, which in 2018 was valued at NZ$252.56 billion (S$216.05 billion). This is forecast to reach NZ$431.20 billion (S$368.86 billion) by 2025 (Food Ingredients Global, 2021).

Competitors

Singapore relies heavily on imports for food, so competition between food and beverage brands is fierce. Competition in the supplements industry is especially tight. At the same time, the country's diverse cultural makeup and consumer base create varied demand for imported products and global brands (NZTE, 2021).

American vitamin retailer GNC has a 50% share of Singapore's health supplements industry. However, third-party retailers such as iHerb and Lazada are gaining traction in Singapore, as consumers increasingly prefer the convenience and competitive pricing of e-commerce platforms (NZTE, 2021). Online healthcare retailer Eu Yan Sang is extremely popular due to its diverse range of traditional medicines and popular snack foods. This provides New Zealand seaweed products with a potential distribution channel to Singapore consumers, as no seaweed products are currently offered on this website (Eu Yan Sang, 2022).

Table 2: Competitors in the Asia-Pacific region in seaweed aquaculture

Company	Region	Business Type	Mission
Blue aqua & stemcell united	Singapore	Joint Venture	• Joint venture between Blue Aqua (aquaculture solutions) and Stemcell United (pharmaceutical company) • Aims to farm sea grapes as sustainable superfoods and plant-based proteins • Has successfully trialled the application of plant stem cell technology on sea grape cultivation • Focus on integrated aquaculture farming systems, with plans to promote seaweed's unique qualities and benefits • Seeking to ensure sustainable food resources are available for future generations and make a significant contribution to Singapore's '30 by 30' strategy
Rhodomax	Malaysia	Start-up	• Seaweed farming and processing sectors in the development of thread, fertiliser, bio-plastics, and leather substitute • Response to greenhouse gas emissions and plastic use within the agricultural sector • Exploring opportunity of seaweed as sustainable biomass of the future • Integrated innovation system maximising seaweed's potential to produce vegan leather, seaweed yarn, etc. • Utilising seaweed's ability to be hugely scaleable and simple to cultivate • Cultivated in Southeast Asia for 50 years, infrastructure is already in place
CH4 Global	New Zealand	For profit	• Global red seaweed supplement company started in Australia • First integrated EcoPark in New Zealand for sustainable aquaculture • Enabling large-scale production of seaweed-based animal supplements for methane mitigation • Reduces enteric methane by 90%
AgriSea	New Zealand	Family owned	• Produces organic seaweed biostimulants and nutritional supplements • Sustainable seaweed harvested from New Zealand beaches • R&D into creating a blue economy, marine activities that generate economic value and contribute to the environment • Uses seaweed to manufacture macro-algae concentrates and bioactive extractions for adding nutrition to soil, plant, animal, and human health

Implementation plan

Given that there is currently no supply chain for farmed seaweed in New Zealand, the first step in investigating this opportunity is to determine how to commercialise the production of seaweed in New Zealand. This will involve determining optimal growing conditions, growing practices, and seaweed species. It will also require investing in infrastructure to support the development of the new aquaculture sector. A pilot scheme in the Hauraki Gulf, which starts in 2023, is a great example of the type of research required and ideally will encourage similar pilots to be established around the country.

In this phase, we also recommend seeking connections with enterprises from Southeast Asia as seaweed aquaculture plays an important role in Asia's economy (Cai et al., 2021). Asia contributed 97% of the total 35.8 million tonnes produced globally in 2019 (FAO, 2021). Cultivation of the eucheumatoid seaweeds *(Kappaphycus* and *Euchema)* is a major contributor to the economy, food supply, and rural livelihoods in the ASEAN region (Cai et al., 2021).

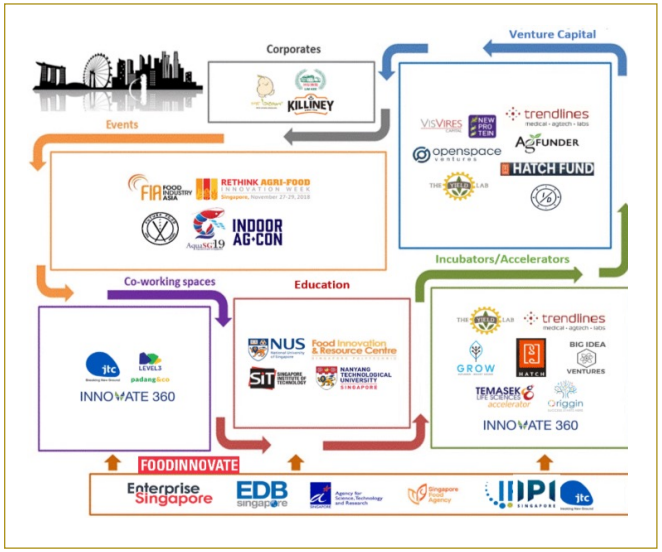
Potential investment sources include:

1. Securing a New Zealand government research grant with potential private sector investment to kickstart the development of a seaweed supply chain.
2. Developing a partnership with businesses from Southeast Asia that have an established seaweed supply chain and can provide knowledge and economic support.

Further down the track, Singapore can be used as a test market for the products that are suggested in this report, and which have been designed in New Zealand specifically for the Southeast Asian market.

Singapore as a base for operations

Singapore has a vibrant food innovation ecosystem, which comprises both local and international players from across the value chain (Enterprise Singapore, 2022), making it an advantageous location to operate a value-added food product venture. The interlaced framework of processes, from research and development to distribution and sales, can support a venture at all stages. This has similar implications for businesses aiming to use Singapore as a test market, where revision and re-evaluation are easily accessed via the education, incubation, and venture capital present in the ecosystem. The following graphic from Enterprise Singapore (2022) provides a snapshot of the ecosystem:



Singapore's food tech ecosystem

Singapore's food tech ecosystem is highly effective with the following key areas:

- **Comprehensive food R&D facilities and shared infrastructure**
  Shared facilities include the High-Pressure Processing (HPP) facility and Small Batch Manufacturing Facility at Senoko Food Hub. The Food Innovation and Resource Centre (FIRC) provides companies with technical expertise and pilot plant facilities.
- **Favourable food regulatory environment**
  Singapore is the first country in the world to approve lab-grown meat for sale.
- **Vibrant and globally connected innovation ecosystem**
  Singapore has five global, best-in-class accelerator programmes. It has built innovation partnerships with advanced markets such as the Netherlands and Australia.
- **Strong investor and corporate interests**
  Singapore has the most investment into food tech start-ups in ASEAN, with S$117 million (NZ$136.77 million) invested in 2019.

Businesses also receive strong government support from the Food Innovate network, which aims to equip Singapore-based companies with resources to create food for the future and to position Singapore as a location of choice for creating food for Asia (Enterprise Singapore, 2022).

Singapore's strong food tech ecosystem makes it an ideal location for businesses that wish to test and incubate a product and operate effectively in the ASEAN region.

Conclusion

There are many bilateral and multilateral agreements between New Zealand and Singapore that facilitate trade and collaboration between the two nations. An already strong demand for nutritional products has been stimulated further by the COVID-19 pandemic. The global stress on the agrifood value chain highlights the need for sustainable and domestically produced sources of food, which could include high value seaweed products.

There is an opportunity for New Zealand farmed seaweed to be processed and sold in Singapore as supplements, seasoning, or as a component of alternative proteins. With over 850 native species of seaweed, New Zealand has raw materials ready for utilisation. Singapore is highly advantageous as a location for operation, being home to a highly effective food tech ecosystem that supports product development and commercialisation, as well as being a test hub for the greater Southeast Asia region.

Recommendations

As highlighted earlier in the report, seaweed extraction, processing, and production requires a high level of investment. This sector is still immature, calling for the development of port and wharf infrastructure, capital investment, and further research and development (New Zealand National Science Challenge, 2022). Additionally, there is a lack of research and consolidated data on how the seaweed sector could scale, what resources are available, and the level of funding required. Furthermore, New Zealand is constrained by its underdeveloped supply chain (NSC, 2022). Seaweed is currently harvested in small volumes that do not accommodate greater international demands.

With these barriers in mind, we recommend the following steps towards the development of high value seaweed products. First, the market for seaweed in New Zealand is immature (NSC, 2022), requiring international markets (where demand is higher) to be targeted. Singapore is not only a hub for innovation, but also possesses advanced technology and infrastructure. Its growing consumer demand for alternative proteins, future foods, and health-oriented products presents an unmatched opportunity for New Zealand's seaweed sector.

Second, New Zealand is known worldwide for its 'clean, green' reputation. Consumers in international markets perceive New Zealand products as highly ethical, sustainable, and trustworthy (NZTE, 2022), which the seaweed sector should leverage. New Zealand's competitive advantage lies in high value seaweed products for niche markets via technology-led extraction from native species (NSC, 2022).

Third, the current lack of data and research in this sector is a challenge for its future development. However, further research and development is being encouraged by government agencies both in New Zealand and Singapore.

Lastly, the development of the seaweed sector must consider environmental impact, Te Tiriti o Waitangi obligations, and bi-cultural consultation. As New Zealand shifts towards a blue economy, understanding the environmental impact of developing a seaweed sector is vital. The commercialisation of seaweed also requires consultation with Māori partners, to ensure practices align with Māori customs and protocols and that they meet all obligations to Te Tiriti o Waitangi. These areas need special attention before New Zealand seaweed is produced and exported at scale.

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References

Agri-Food Tech Expo Asia. (2022, 9 March). *Seaweed Aquaculture's Untapped Potential*. Retrieved from https://agrifoodtechexpo.com/2022/03/09/seaweed-aquacultures-untapped-potential/

Birch, Dawn; Skallerud, Kåre; Paul, Nicholas A.(2018) *Who are the future seaweed consumers in a Western society? Insights from Australia*, British Food Journal, Article publication date: 12 December 2018. Retrieved from https://www.emerald.com/insight/content/doi/10.1108/BFJ-03-2018-0189/full/html

Cai Junning, Lovatelli Alessandro, Aguilar-Manjarrez José, Cornish Lynn, Dabbadie Lionel, Desrochers Anne, Diffey Simon, Garrido Gamarro Esther, Geehan James, Hurtado Anicia, Lucente Daniela, Mair Graham, Miao Weimin, Potin Philippe, Przybyla Cyrille, Reantaso Melba, Roubach Rodrigo, Tauati Mele, Yuan Xinhua (2021). *Seaweeds and microalgae: an overview for unlocking their potential in global aquaculture development. FAO Fisheries and Aquaculture Circular*, (1229), 48p. Retrieved from https://doi.org/10.4060/cb5670en

Enterprise Singapore. (2022). *Growing Singapore's AgriFood Tech Ecosystem* [presentation]. Centre for Asia Pacific Excellence Tertiary Market Immersion Programme 2022.

Enterprise Singapore. (2022). *Industry Profile*. Retrieved from https://www.enterprisesg.gov.sg/industries/type/agri-tech/industry-profile

Fletcher, R. (2020, 21 August). *The Malaysian start-up that aims to take the seaweed sector by storm*. Retrieved from https://thefishsite.com/articles/the-malaysian-startup-that-aims-to-take-the-seaweed-sector-by-storm

Food Ingredients Global. (2021). *How is Covid-19 shifting demand for health ingredients?* Retrieved from https://insights.figlobal.com/health-wellness/how-covid-19-shifting-demand-health-ingredients

Food Navigator, (2022) *Super nutritious 'enriched seaweed' that can help ease global food crisis unveiled by scientists*. Retrieved from https://www.foodnavigator.com/Article/2022/09/05/super-nutritious-enriched-seaweed-that-can-help-ease-global-food-crisis-unveiled-by-scientists?utm_source=copyright&utm_medium=OnSite&utm_campaign=copyright

Grand View Research (GVR), (2019) *Seaweed Snacks Market Size, Share & Trends Analysis Report By Product (Bars, Strips & Chips, Flakes), By Distribution Channel (Offline, Online), By Region, And Segment Forecasts,* 2020–2027 Retrieved from https://www.grandviewresearch.com/industry-analysis/seaweed-snacks-market

Harvard T.H. Chan. School of Public Health (2022). *The Nutrition Source: Iodine*. Retrieved from https://www.hsph.harvard.edu/nutritionsource/iodine/

Holmyard, N. (2020, 29 October). *New report dives into seaweed production and its untapped European potential*. Retrieved from https://www.seafoodsource.com/news/supply-trade/new-report-dives-into-seaweed-production-and-its-untapped-european-potential

LEARNZ. (2022). *Seaweed: An ocean of opportunity*. Retrieved from https://www.learnz.org.nz seaweedaquaculture211

Lordan R. (2021). Dietary supplements and nutraceuticals market growth during the coronavirus pandemic - Implications for consumers and regulatory oversight. *Pharma Nutrition*, 18, 100282.

New Zealand Ministry of Foreign Affairs and Trade. (2019). *New Zealand–Singapore Enhanced Partnership*. Retrieved from https://www.mfat.govt.nz/en/countries-and-regions/asia/singapore/

New Zealand Ministry for Primary Industries. (2019). *Commercial seaweed aquaculture to reduce agricultural methane emissions*. Retrieved from https://www.mpi.govt.nz/dmsdocument/37892/direct

New Zealand Ministry for Primary Industries. (2021, 9 December). *Pilot project aims to establish commercial seaweed farming sector in New Zealand*. Retrieved from https://www.mpi.govt.nz/news/media-releases/pilot-project-aims-to-establish-commercial-seaweed-farming-sector-in-new-zealand/

New Zealand National Science Challenge (NSC) (2019, May). *Agrisea — a blue economy success story*. Retrieved from https://www.sustainableseaschallenge.co.nz/tools-and-resources/agrisea-a-blue-economy-success-story/

New Zealand National Science Challenges. (2020). *Building a Seaweed Sector*. Retrieved from https://www.sustainableseaschallenge.co.nz/our-research/building-a-seaweed-economy/

New Zealand National Science Challenges. (2022, October). *Aotearoa New Zealand's Seaweed Sector Framework*. Retrieved from https://www.sustainableseaschallenge.co.nz/tools-and-resources/seaweed-sector-framework/

New Zealand Trade and Enterprise. (2022, 26 April). *Is Singapore the right market for your supplements? Retrieved* from https://my.nzte.govt.nz/article2/is-singapore-the-right-market-for-your-supplements

New Zealand Trade and Enterprise. (2021, 15 April). *The competitive landscape in Singapore's supplements market*. Retrieved from https://my.nzte.govt.nz/article2/the-competitive-landscape-in-singapores-supplements-market

New Zealand Trade and Enterprise. (2022). *Singapore's food and beverage retail sector*. Retrieved from https://my.nzte.govt.nz/article2/singapores-food-and-beverage-retail-sector

Ogilvie, O. (2021). *Cellular agriculture*. Office of the Prime Minister's Chief Science Advisor. Retrieved from https://www.pmcsa.ac.nz/topics/cellular-agriculture/

Pacific Harvest. (2022). *Trusted Seaweed Specialists*. Retrieved from https://pacificharvest.co.nz/

The Fish Site. (2020, 14 October). *Grape expectations: novel superfood seaweed farm launched in Singapore*. Retrieved from https://thefishsite.com/articles/grape-expectations-novel-superfood-seaweed-farm-launched-in-singapore

The Fish Site. (2022, 1 September). *CH4 Global builds full-scale EcoPark in New Zealand*. Retrieved from https://thefishsite.com/articles/ch4-global-builds-full-scale-ecopark-in-new-zealand

The Nature Conservancy. (2021, 25 June). *Restorative Aquaculture Has Positive Impacts on Marine Life*. Retrieved from https://www.nature.org/en-us/newsroom/habitat-value-of-aquaculture-study-june-2021/

Wheeler, T., Major, R., Ogilvie, S., South, P., Romanazzi, D. & Adams, S. (2021). *Stocktake and characterisation of New Zealand's seaweed sector: Species characteristics and Te Tiriti o Waitangi considerations*. Retrieved from https://www.sustainableseaschallenge.co.nz/assets/dms/Reports/Seaweed-sector-review-part-2-Attributes-and-Te-Tiriti/Seaweed-characteristics-and-Te-tiriti-considerations.pdf

Thiviya, P.; Gamage, A.; Gama-Arachchige, N.S.; Merah, O.; Madhujith, T. Seaweeds as a Source of Functional Proteins. *Phycology* 2022, 2, 216–243. Retrieved from https://doi.org/10.3390/phycology2020012

United Nations University, UNU CRIS (2021) *Sustainable Value Chain for the Seaweed Industry in Malaysia and the ASEAN region: A Roadmap for Policy Formulation*. Policy Brief 08 2021. Retrieved from Institute of Comparative Regional Integrative Studies (CRIS) United Nations University. https://cris.unu.edu/sites/cris.unu.edu/files/PB21.08%20%20GSSTAR%20Malaysia%20and%20ASEAN.pdf

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