National Science Challenges

Centre for High-Value Nutrition

HIGH-VALUE NUTRITION

Ko Ngā Kai Whai Painga

Revised Business and Science Plans

17th December 2014

Host Institution

This revised Research Plan and Business Plan was prepared by the Directorate, Professor David Cameron-Smith, Eflamm Allain and Dr John Smart, in collaboration with the Science Leadership Team, with the expertise from members of the Expert Panels, and with input from this Challenge's Board, Science Advisory Panel and Industry Advisory Panel.

High-Value Nutrition is deeply appreciative of the considerable in-kind support received from across the New Zealand research community and advisory panels, and the Establishment phase funding provided by MBIE.

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EXECUTIVE SUMMARY

High-Value Nutrition (HVN) is a New Zealand National Science Challenge with the mission to increase food and beverage (F&B) export revenue through leadership in the science of food and health relationships.

F&B exports have grown significantly and are now the largest source of trade export earnings for New Zealand. The increased demand is predominately from Asia. Further revenue growth is possible by transforming the still largely unprocessed or minimally processed exports into higher value branded products that meet the expectations of consumers. Market data clearly indicates that food for health, and in particular food with validated health benefits, is a motivator of consumer choice and is an increasing major global opportunity. The willingness from businesses to closely engage with this Challenge is a strong sigonal that the New Zealand F&B industry is likely to be able to capture this opportunity. The development of this National Science Challenge is thus not only very relevant to New Zealand, but very timely.

Sustained revenue growth can be achieved by developing manufactured F&B products that meet consumer needs and that are supported by scientific substantiation of health benefits. HVN is one component of a combination of policy towards foods-for-health across ministries and agencies underscoring the New Zealand government's commitment to design a smart stimulus package that goes from research investment to regulatory, via commercialisation and market access support to best enable the New Zealand industry to capture this food-for-health export opportunity.

To guide its research and ensure it remains focussed on this economic mission, HVN is placing the needs of consumers in New Zealand's export markets at the centre of its research programme, thus taking commercial opportunities as its line of sight.

HVN will complete its mission through achieving the following goals:

- Identify food for health opportunities through greater consumer insight;
- Undertake research of international excellence that identifies the key mechanisms and associated biomarkers that generates new opportunities for food-for-health benefits;
- Link the science of food and clinical trial practice and management to accelerate the validation of food-health relationships;
- Combine consumer insights with research knowledge of clinical benefit (including biomarkers), and the science of food to create a significant proposition for New Zealand F&B industry uptake and benefit.

To ensure the outcomes of its research are relevant to the New Zealand F&B industry in 10 year time, HVN undertook a foresight strategic planning exercise to identify opportunities. To also ensure alignment with industry HVN established and consulted an Industry Advisory Panel comprising of eminent F&B businessmen, as well as directly surveying F&B businesses. 40 scientists and experts from across the New Zealand identified 18 opportunities, and prioritised down to three that are currently worthy of investment.

HVN is directing its research funding towards three health targets aligned with consumer mega-trends and established demographic demands for functional health foods:

- Metabolic Health;
- Gastrointestinal and Immune Health;
- Weaning Foods for Health.

To support progress towards the mission HVN has established strong governance, management and leadership, and is developing a virtual centre of excellence, that will not only coordinate scientific activities but act as a one-stop-shop for the New Zealand industry to access the necessary knowledge to successfully launch food-for-health product in export markets.

OVERVIEW

THE CHALLENGE

Designed for science excellence and impact

ROLE AND PURPOSE

High Value Nutrition (HVN) is a multi-disciplinary national research collaboration with strong industry engagement designed to enable an increase in New Zealand's export earnings from foods and beverages (F&B) that have scientifically validated health benefits.

Food and Beverage (F&B) products account for 56% of New Zealand's merchandise trade exports. Within this, New Zealand is a significant global trader in selected areas including dairy products, lamb, beef, kiwifruit, apples and seafood. One-third of New Zealand exports leave the country unprocessed and less than 10% is added-valued processed F&B products.

In 2012, the Business Growth Agenda (BGA) defined the New Zealand government's goal to more than double F&B export revenues to roughly $50B pa by 2025.

- Reaching the BGA goals will require a significant increase in revenues from exported F&B products and cannot be achieved by increasing production alone and will require generating more value from our products in market.
- Strategies to further increase revenue from F&B exports are required.

Internationally, annual growth in the sales of premium F&B products that deliver a health benefit exceeds the growth from commodity foods and ingredients. New Zealand has a significant opportunity to grow export returns in added-value F&B products that deliver health benefits to the consumer. F&B products, with potential for high profitability, that are marketed on their health benefits to consumer, build upon the followed strengths of New Zealand:

- An established reputation as a country of origin of high quality F&B products that are produced in a unique environment, with excellent primary productions systems and high food safety standards.
- The Food Standards Australia and New Zealand (FSANZ) food-for-health regulation enables the sale of foods with validated health benefits and claims

HVN has responded to the opportunity to add significant value to F&B products of New Zealand origin through an increased scientific understanding of food-health relationships. This Challenge will position the New Zealand F&B sector as an international leader in the production and export of foods with validated health benefits. This will be achieved through coordinated research investment and science leadership linking the health benefits desired by consumers to the F&B products that can be manufactured and exported from New Zealand.

OUR VISION

Growing New Zealand food and beverage export revenue through international leadership in the science of food and health relationships

OUR MISSION

Develop high-value foods with validated health benefits to drive economic growth through research excellence in the following research themes:

- Clinical application (what foods do what);
- Biomarkers (measuring impact, clarifying risk);
- Meeting consumer preferences and health value;
- Science of food.

The aim of the HVN Challenge is thus to increase the value of New Zealand food exports by improving the value proposition to consumers through a health claim on the food leading to increased premiums and/or increased sales volume. Research under all themes will be relevant to the health targets, regulatory needs, consumer preferences/values, and the food types that offer the greatest economic opportunity to New Zealand through food exports.

OUR SCOPE OF OPERATIONS

The HVN National Science Challenge will achieve its mission by:

- Establishing a virtual centre of excellence;
- Supporting research, science or technology or related activities to achieve the mission;
- Focusing on the health relationships of food and beverage products;
- Focusing on food and beverage products as defined by Food Standards Australia and New Zealand (FSANZ).

OUR ROLES

HVN will do so by fulfilling the following roles:

- Investing to build world-leading research capabilities in food-health relationships that provide the platforms for future product and market innovation;
- Investing in novel science and innovation opportunities;
- Building researcher skills and expertise in the science of high-value nutrition, including Māori researchers, that will catalyse development of evidence based health foods;
- Coordinating and leveraging research across New Zealand that is aligned to High-Value Nutrition through a virtual centre of excellence;
- Actively engaging with leading international organisations and research groups relevant to High-Value Nutrition to access regulatory knowledge, research capabilities, build relationships and influence;
- Aggregating, integrating and communicating scientific knowledge relevant to the priority consumer health targets to become an internationally recognised authority in food-health relationships and health claims;
- Developing pathways for research translation and engagement to enable New Zealand industry to increase economic returns through the development and marketing of evidence based health foods.

OPERATING STRUCTURE

HVN is a multi-party virtual research centre structured to engage effectively with the research and F&B manufacturing capabilities across New Zealand. The operating structure is designed to create the necessary momentum directed towards achieving the mission.

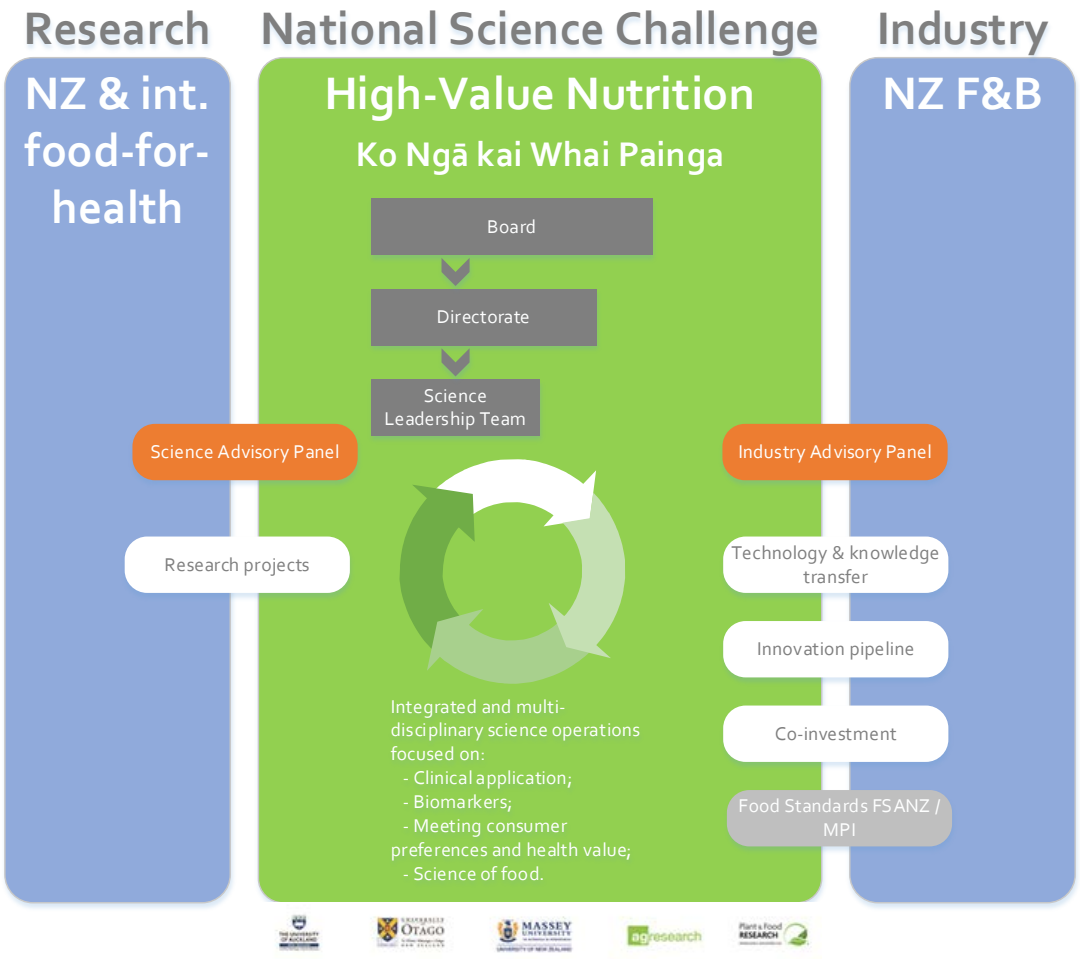


Fig.2 – High-Value Nutrition operating structure

OPERATING AGREEMENTS

The University of Auckland has entered into a National Science Challenge Investment Contract (NSCIC) with the Ministry of Business, Innovation and Employment (MBIE) for the delivery of the Challenge. Included within the NSCIC is a Collaboration Agreement between the Challenge Members (the Parties); AgResearch, Massey University, Otago University, Plant & Food Research and the University of Auckland. The Parties have executed the Collaboration Agreement which establishes the HVN Board and management structure. The agreement devolves responsibility for the operation and performance to the HVN Board.

- HVN is a virtual centre, with central directorate at the University of Auckland and operational activities across New Zealand Research, Science and Technology (RS&T) organisations.
- All New Zealand RS&T organisations, not just Challenge Members, can be sub-contracted to deliver the science.
- HVN is a NZ Inc. collaborative and multi-disciplinary research collaboration to achieve the mission.

THE CENTRE FOR HIGH-VALUE NUTRITION

HVN's role goes beyond investing in and managing research and there is a strong expectation for it to play an "aggregator" function to achieve its mission. This requires the establishment of a world-class Centre of Excellence with:

1. Outstanding science leadership, including:
    - The ability to rally and lead the national research agenda;
    - Influencing the international research agenda;
    - Engaging with national and international food regulators;
    - Facilitating commercialisation of research with industry;
    - Outreach through technical communications, with opinion articles, statements of evidence, systematic reviews and other publications that encompass the science activities of HVN and the broader food & health environment.

2. Advancing collaborations with the New Zealand F&B industry, including:
    - Promote HVN as the one-stop-shop with regards to food for health for industry;
    - Direct, ongoing, and active liaising with industry;
    - The ability to facilitate commercialisation through HVN's partners;
    - Effective and exhaustive knowledge transfer to industry;
    - Integration and management of industry inputs into HVN's research programme;
    - Influencing industry to seize the food for health opportunity.

Consequently there is a need for the centre of excellence to include leadership, management and technical competencies in addition to the demanding administrative and operational requirements to support the devolved funding operation.

Five broad functional categories have identified and are required for the effective operation of HVN to achieve its mission:

- National Science Leadership, with respect to 'Foods for Health' & 'Food-Health Claim Substantiation';
- Industry Liaison and Commercialisation;
- Governance and Advisory;
- Communications, Marketing and Outreach;
- Administration, Management and Operations.

These functions have formed the basis of HVN's resourcing needs in addition to the main research investment categories articulated in the budget (Appendix 1).

HIGH VALUE NUTRITION BOARD

HVN has established a Board which has the necessary background, breadth of skills and extensive experience. The skills matrix for the Board and brief biographies of each Board member are included in Appendix 2. All Board members are bound by a Terms of Reference which outlines their roles and responsibilities (Appendix 3).

Since April2014 the Establishment HVN Board have met monthly to inform on strategy, provide oversight and monitor performance to MBIE's stated expectations and contract agreements

- The Board (2015 – ongoing) will continue to provide oversight and governance with quarterly meetings, coinciding with the cycle of financial reporting and alignment of annual planning and reporting.
- Annual joint meeting with the Science Leadership Team, the Science Advisory Panel and the Industry Advisory Panel will inform the science and industry aspects of the HVN Challenge.

HVN has also developed robust governance processes with standard review of conflicts register, approval of minutes, financial reporting, review of progress against plan, scrutiny and approval of management recommendations for all matters pertaining to the development of the HVN research and business plans.

DIRECTORATE AND OPERATIONS

During the Establishment Phase, Professor David Cameron-Smith was Establishment Director and Chaired the Science Leadership Team. Together with Dr John Smart (Director Research Partnerships) and Eflamm Allain (Operations & Communications Manager) this operational team has been responsible for management and operational activities.

The Director and staff will operate to fulfil the Collaboration Agreement consistent with the expectations of the Challenge Contracts with MBIE (see Appendix 3 role of Director).

SCIENCE ENGAGEMENT – NEW ZEALAND

Development and planning for HVN has drawn upon the skills and expertise of the collective knowledge of scientists across the RS&T organisations of New Zealand. Nominated by Challenge Members and approved by the HVN Board, the Science Leadership Team (SLT) were key scientists engaged in the development of the scientific agenda and the prioritisation of the research programme. The SLT members achieved this by chairing Expert Panels, who provided further breadth and depth of science knowledge. The Expert Panels were established through a nationwide call which generated over 80 nominees of eligible scientists and technical experts wishing to participate in the Challenge. The Directorate and SLT collaboratively selected Panel members on the basis of expertise, skills and experience, 4 to 5 scientists for each of the 6 Expert Panels. The Expert Panels, including membership and process was approved by the HVN Board.

Table 1 - Science Leadership Team


Dr Nicole Roy - AgResearch


Dr Lisa te Morenga - University of Otago


Professor Sally Poppitt - University of Auckland


Professor Marlena Kruger – Massey University


Professor Harjinder Singh – Massey University


Dr Roger Harker - Plant & Food Research


Dr Lisa Houghton – University of Otago


Dr Roger Hurst - Plant & Food Research

Table 2 - Expert Panels

Gut & Immune Health	
- Elizabeth Forbes-Blom - Malaghan Institute	- Karl Fraser - AgResearch
- Richard Gearry - University of Otago	- Shane Rutherfurd - Massey University
- Janine Cooney - Plant & Food Research	
Maternal & Child Health	
- Alison Hodgkinson - AgResearch	- Julia Rucklidge - University of Canterbury
- Paul Hofman - The University of Auckland	- Gerald Tannock - University of Otago
Meeting Consumer Preferences & Health Values	
- Denise Conroy - The University of Auckland	- Bill Kaye-Blake - PWC
- Sara Jaeger - Plant & Food Research	- Phil Bremer - University of Otago
Metabolic Health	
- Jan Huege - AgResearch	- Justin O'Sullivan - The University of Auckland
- John Ingram - Plant & Food Research	- Paul Moughan - Massey University
Mobility	
- Nicola Dalbeth - The University of Auckland	- Cameron Mitchell - The University of Auckland
- Martin Dickens - Massey University	- Stephen Stannard - Massey University
The Science of Food	
- Richard Archer - Massey University	- Simon Loveday - Massey University
- Charles Brennan - Lincoln University	- Jolon Dyer - AgResearch
- Phil Bremer - University of Otago	

SCIENCE ENGAGEMENT – INTERNATIONAL

Internationally renowned scientists with expertise applicable to the HVN mission were recruited to contribute to the Science Advisory Panel (SAP) for 3 years initially. The SAP provides comments and insights during the establishment, implementation and review of research programmes and projects. The SAP has provided feedback during the research prioritisation planning process, completed in 2014. The SAP will be invited to site visits and the annual science forum to commence in 2016.

Table 3 - Science Advisory Panel

	Professor Phillip Calder, Professor of Nutritional Immunology, Human Development & Health, Academic Unit, Faculty of Medicine, University of Southampton, UK
	Professor Sean Strain, Professor of Human Nutrition & Director, Northern Ireland Centre for Food and Health (NICHE), University of Ulster, Ireland
	Professor Yang Yuexin, President Chinese Nutrition Society, Director, Department Food Nutrition and Assessment, National Institute of Nutrition and Food Safety, Beijing, China
	Professor Bruce German, Director, Foods for Health Institute, Department of Food Science & Technology, University of California, USA
	Professor Connie Weaver, Distinguished Professor and Department Head, Director, Women's Global Health Institute, Purdue University, USA

INDUSTRY ENGAGEMENT

Business leaders were recruited to the Industry Advisory Panel (IAP) on the basis of their experience and knowledge of the F&B industry, food-for-health market, strategy development, and science/industry relationships. The terms of reference of the IAP are to provide advice and insight to ensure the alignment of research investment with the New Zealand F&B industry and to support effective industry engagement and commercialisation models for HVN.

The IAP has confirmed that the consumer led strategic approach is beneficial to the NZ F&B industry. Further, for HVN to achieve the mission, leverages from existing strengths are required. This includes;

- Aligning with NZ "sweet spot" of naturally healthy foods;
- Integrity of regulatory and production systems;
- Quality and reputation of our science;
- Sets the global standards for regulatory approvals and science collateral for nutritional food products.

These insights have been embedded in our development of the research and business plans.

Table 4 - Industry Advisory Panel


Jeremy Hill (Fonterra)


Brett Hewlett (Comvita)


Mark Wynne (Balance AgriChemicals)


Dave Tanner (Zespri)


Gerard Hickey (First Light)

VISION MĀTAURANGA

Vision Mātauranga (VM) seeks to unlock the potential of Māori knowledge, resources and people through science and innovation via four themes focussing on: economic innovation, taiao/environmental sustainability, hauora/improving health and mātauranga/indigenous innovation. To ensure greater awareness and knowledge of Vision Mātauranga, Māori cultural perspectives, the Māori economy and Māori F&B businesses within HVN the following activities and ongoing engagements have/are being made:

- **Awareness.** The HVN Directorate has greatly increased their awareness and knowledge of Vision Mātauranga, Māori cultural perspectives, the Māori economy and Māori F&B businesses through attendance at a noho marae as part of the NZ Trade and Enterprise Kia Kaha programme at the Otaki marae of Raukawa.
- **HVN Management and Operation.** Commitment to VM has ensured strong Māori voices are present at management, advisory and governance structures. These include Paul Morgan and Mavis Mullins on the HVN Board who bring in depth experience of Māori business and cultural perspectives to governance. A Maori business leader is to be recruited to the Industry Advisory Panel and Lisa Te Morenga has championed Vision Mātauranga in the Science Leadership Team.
- **Engaging with entrepreneurial Māori F&B businesses.** HVN has a mission aligned with economic growth, achieved through the scientific validation of food health relationships. Thus VM and HVN alignment, as well as alignement with He Kai Kei Aku Ringa, is primarily through economic innovation relating to Māori owned primary production based assets and the emerging F&B businesses. Many of these Māori assets are developing significant entrepreneurial activities - HVN's approach is to engage collaboratively with these businesses. The HVN Board member (Paul Morgan) invited the HVN Directorate to a meeting of the Nuku ki te Puku group of Māori business leaders – a cohort involved in a recent North America F&B mission and development programme at Stanford University with Callaghan Innovation. Interaction with this group will follow into early 2015, to establish an ongoing mechanism to bring Māori based innovation thinking into HVN.
- **Investment.** Aspects of VM will be supported, where relevant, across Priority Research programmes and will be supported explicitly via contestable funding where projects with Māori business partners, Māori PhD students and Postdoctoral researchers are involved. Building Māori capabilities aligned with the HVN strategy to lift the New Zealand F&B sector up the value chain will both benefit Māori and also leverage the unique characteristics Māori bring to the sector into HVN for New Zealand's wider benefit.
- **Researchers.** Initial contact with a Māori Kahui, which was established to support 3 Health and Wellbeing National Science Challenges has been made and will be developed in parallel with them in 2015 as those Challenges are developed. We see value in seeking advice from this group (due to the natural overlap in many of the health research areas with HVN) on Māori research advisory input.

Ensuring these strong Māori voices within HVN is intended to support the integration of Māori into the Challenge.

PERFORMANCE FRAMEWORK

The performance of the Challenge will ultimately be measured against the goal of increasing exports. However, at a more granular level, HVN has developed a roadmap for monitoring performance over its 10 year horizon leading to the intended outcomes and impacts as illustrated below.

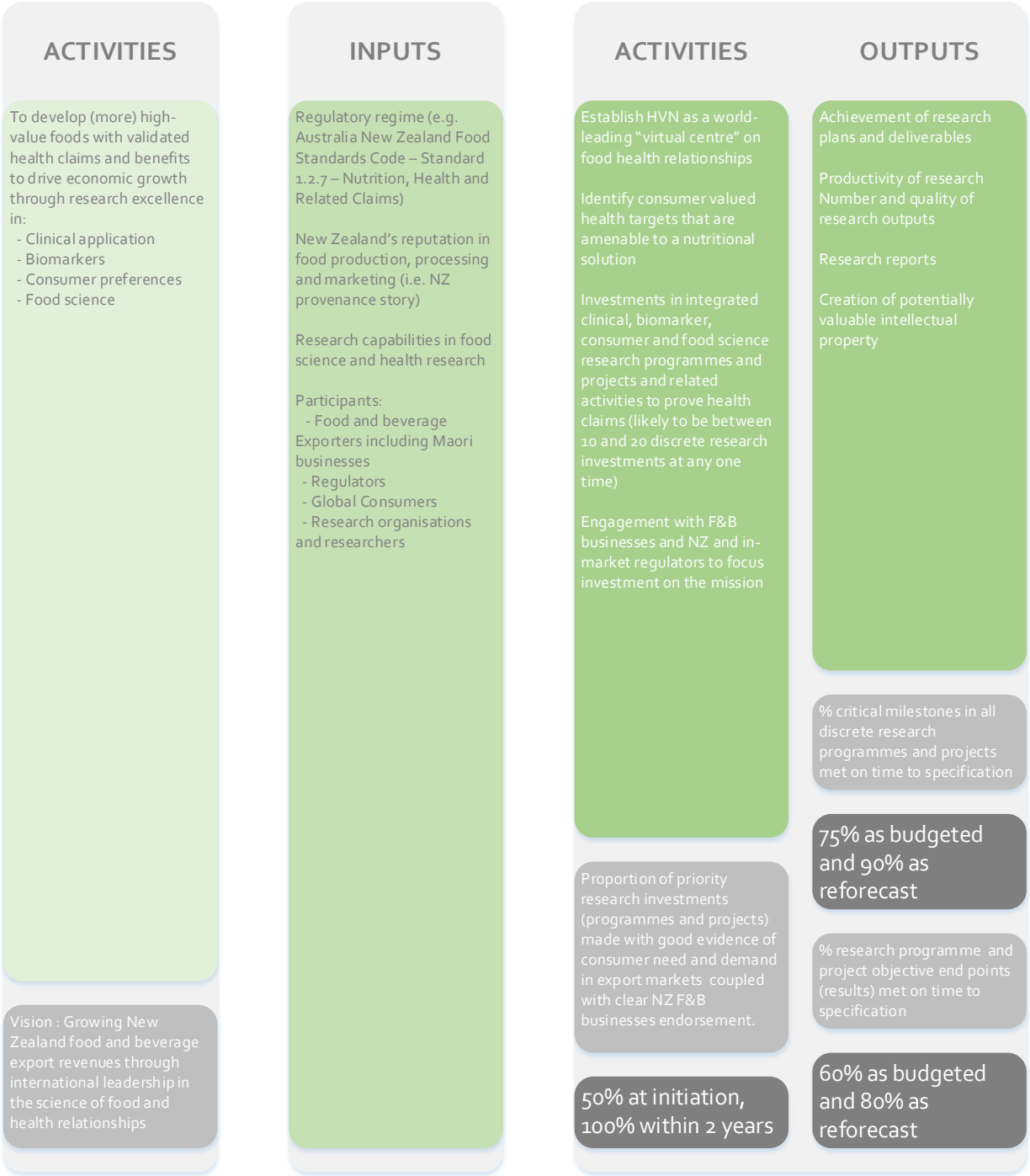
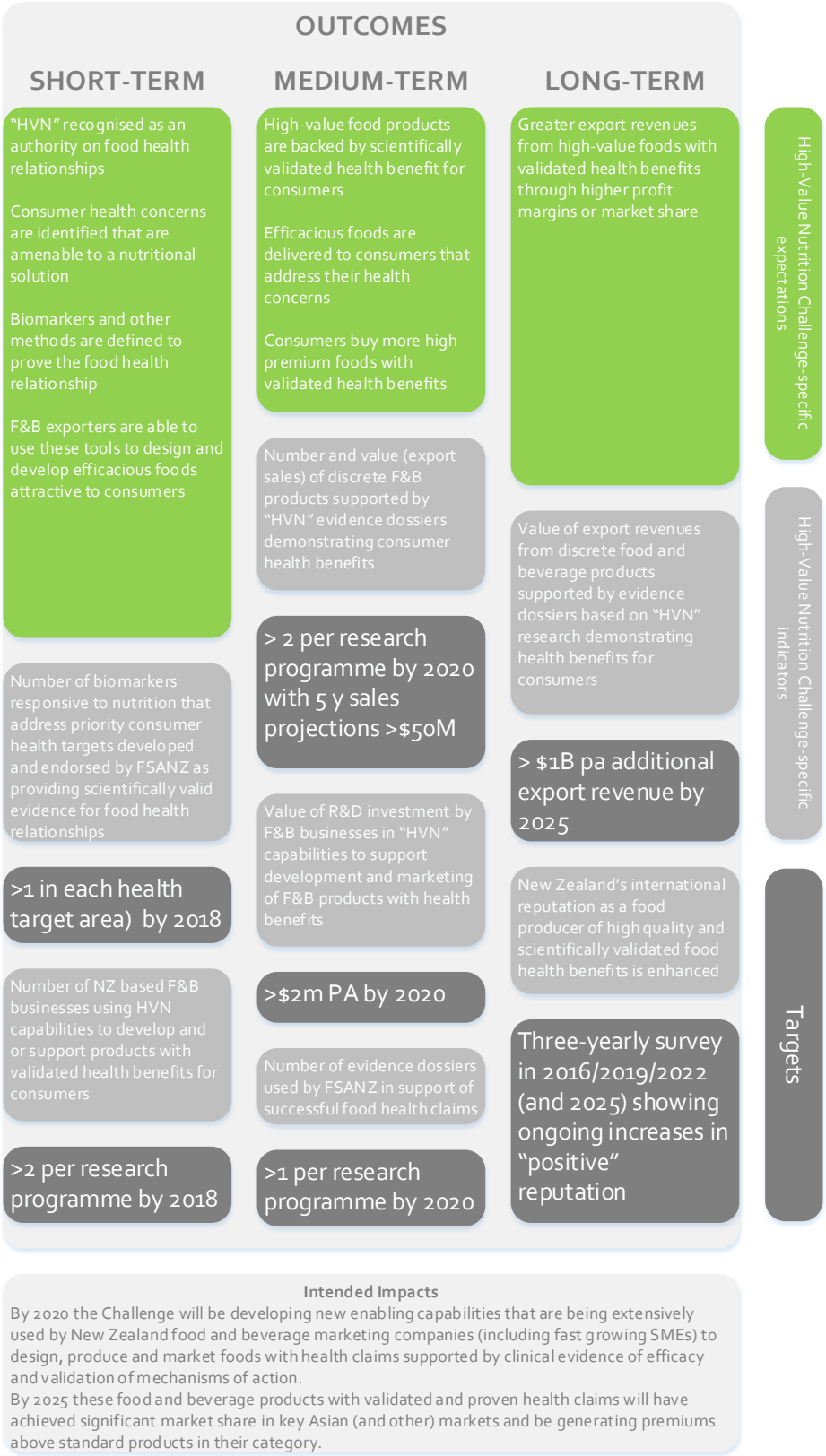


Fig. 1 – High-Value Nutrition draft performance framework



Intended Impacts

By 2020 the Challenge will be developing new enabling capabilities that are being extensively used by New Zealand food and beverage marketing companies (including fast growing SMEs) to design, produce and market foods with health claims supported by clinical evidence of efficacy and validation of mechanisms of action.

By 2025 these food and beverage products with validated and proven health claims will have achieved significant market share in key Asian (and other) markets and be generating premiums above standard products in their category.

A DYNAMIC ENVIRONMENT

Understanding the food-for-health landscape for greater impact

HVN must be effective in integrating and partnering with many organisations that have activities in the 'food for health' spaces. This includes the important relationship with the F&B industries of New Zealand. Important also is the regulatory frameworks that cover health claims. The relationships between food production and human health includes a broad range of existing agencies, research organisations, research capabilities and funded programmes.

THE FOOD & BEVERAGE INDUSTRY

DOMESTIC - NEW ZEALAND

New Zealand is a southern hemisphere temperate country with an ecology and rainfall conducive to diverse agriculture and the surrounding Pacific Ocean is rich source of marine life. The agricultural product has followed that of English colonies, with establishment of red meat (beef and sheep) and dairy industries. Horticultural production included potatoes, apples and carrots are major domestic staple crops. While, marine productivity was predominately ocean catch. For the past decade New Zealand F&B exports have experienced strong growth, with processed foods, beverages and dairy being the best performing categories. This growth has been achieved through increased productivity (i.e. greater herd size and productivity per cow), but also with increasing sophistication of production and manufacture (i.e. infant formula) and new varieties and types of products (i.e. kiwifruit). F&B is exported to a wide range of countries, with Asia growing most significantly. Asia now imports 40% of New Zealand F&B exports, with China being the largest single country.

The New Zealand F&B industry currently spans 2,600 companies, employing almost 85,000 people. Most businesses are small and serve the domestic market. On the other hand, Fonterra is a major dairy trader as well as having significant Consumer and Food Service businesses and alone accounts for 40% of total F&B exports. In terms of export sales, there is a large total sales gap to the next group of medium to large exporting companies, including; red meat (Alliance Group, ANZCO Foods), processing (Goodman Fielder), horticulture (Zespri, Turners & Growers), dairy (Westland, Synlait, Tatua) and bioactives (Comvita). Beyond these groups there are a large number of small to medium F&B businesses across the value chain from production to market. We anticipate only a small subset of these F&B businesses will be strongly strategically aligned with the HVN mission – these will be the focus for our engagement.

HVN is -

- Acting to operate collaboratively with the segment of the New Zealand F&B industry to impact on F&B exports via validated food health claims and benefits for consumers.
- Working in accordance with the Operating Principles that HVN is to coordinate and aggregate pre-competitive knowledge to be the research leaders of regulatory expertise that enables New Zealand F&B companies to grow export markers through validated health claims.
- Working to gain a comprehensive understanding of the strategic direction and capabilities of industries operating to increase export sales of New Zealand F&B sold with health claims or health benefits for their consumers.

INTERNATIONAL

New Zealand F&B exports include commodity and specialised ingredients that are used in branded food products manufactured by foreign owned companies. However, validated health benefits can only be attributed to whole foods, rather than the constitutive ingredients.

International research collaborations and food development opportunities with food multi-nationals may arise on the basis of HVN expertise.

HVN will -

- For New Zealand derived specialised or unique ingredient(s), a case by case analysis will be applied to research investment on the basis of increased economic returns to New Zealand.
- HVN will collaborate with international F&B companies when there is economic benefit for New Zealand.

FOOD AND HEALTH REGULATORY ENVIRONMENT

FOOD HEALTH REGULATIONS - NEW ZEALAND

Food Standards Australia and NZ (FSANZ) Standard 1.2.7 (*Nutrition, Health & Related Claims)* commenced 18th January, 2013. Full compliance to Standard 1.2.7 will be required from 18th January 2016 for all Australian and NZ companies.

FSANZ Standard 1.2.7

A health claim refers to a relationship between a food and health rather than a statement of content.

General Level Health Claims
To date, FSANZ has established 200 pre-approved general level health claims**.** Common statements within the pre-approved general health claims are that the foods either contribute to, or are necessary for the maintenance of normal physiological functioning. These health claims must not refer to a serious disease or to a biomarker of a serious disease.

New general level health claims can be self-substantiated. This requires a F&B company to maintain a dossier composed of a systematic review of scientific substantiation created specifically for the purposes of the claim or a published systematic review, with the necessary updating required for ensuring analysis of most currently available published data. General level health claim wording will not be prescribed, although claims will be subject to audit.

High Level Health Claims
Food health claims that pertain to the ability of a food to reduce the risk of disease or improve the disease management are classified as high level. High level health claims refer to a nutrient or substance in a food and its relationship to a serious disease or to a biomarker of a serious disease. There are currently only 13 pre-approved food-health relationships for high-level health claims. These claims have not been updated since the Standard was gazetted. Included are 3 causes of ill-health (and their well characterised risk factors).

- Heart health is mentioned twice and further covered by an additional 5 statements on risk factor reduction, including total cholesterol and/or LDL-cholesterol and blood pressure.
- Osteoporotic risk reduction is covered with an additional 5 statements (i.e. enhances bone mineral density, reduces risk of osteoporosis and reduces risk of osteoporotic fracture).
- One statement relates to neural tube defects.

Lodgement of high-level health claims requires a systematic review of the evidence supporting the food-health relationship. This will be considered by a FSANZ Health Claims Scientific Advisory Group before pre-approval. The wording of high level health claims will be prescribed.

HVN is –

- Aiming to be a virtual centre of excellence, delivering the scientific excellence and capabilities required for New Zealand F&B companies to achieve FSANZ health claim substantiation on new products to be sold in export markets.
- To be a vehicle for food industry engagement with the regulatory agencies to ensure effective dialogue and improvement of F&B Industry knowledge of the regulatory environment.

FOOD HEALTH REGULATIONS - INTERNATIONAL

Around the world the food health claim regulatory environment is complex and in a state of significant flux. Even within geographical regions (including Asia) food labelling and marketing regulations vary considerably.

Europe

The European Food Standards Agency (EFSA) has been at the forefront of the regulatory environment. In the two year period between July 2008 and March 2010 EFSA reviewed 4637 food-health claims. Success rates are low, with considerable uncertainty of the basis of EFSA decisions, although continued refinement and continual publication of outcomes and the basis of the decisions has improved the current viewed best-practice. Consistently EFSA has maintained 3 key principles –

1. The food responsible for the claimed effect must be fully characterised and the active component(s) identified. This requires chemical and biochemical analyses.
2. The claimed effect must be properly defined and must be measureable. This requires evidence of a mechanism provided through *in vitro* and *in vivo* studies.
3. There must be direct evidence of a measureable human physiological benefit to substantiate the claim. This requires robust human intervention (clinical) trials.

North America
The US Food and Drug Agency (FDA) is primarily focused on food safety and despite the ability to review and issue health claims on the basis of a qualified health claim in food labelling, very few successful claims have been made. Key to the lack of application success is the statement "significant scientific agreement" which is reviewed in the strictest of terms by the FDA.

Canada has also adopted a similar food-for-health substantiation model as FSANZ. Ministry of Primary Industries (MPI) are reviewing regulatory equivalence and approaches. Canada Health strategy for analysis of clinical trial evidence and systematic reviews are likely to have relevance to the FSANZ model

Asia
Within Asia the food-health regulatory environment is complex. China, Japan, Korea and Singapore, as major export countries, each maintain separate food-health claims legislation. Exemplifying the current complexity are the proposed changes and regulatory uncertainty in the largest of the New Zealand's F&B export countries: China and Japan

China: Since 2009, the Food Safety law which is enforced by the State Food and Drug Administration (SFDA) has maintained 27 pre-approved categories for health functions claims. A draft proposal introduced in 2011 may reduce its number to 18, with an EFSA style process emphasising human clinical data.

Table 5 - Categories of health functions claims approved by SFDA (China)

- Enhancing immune systems	- Eliminating skin pigmentation	- Assisting blood pressure reduction
- Sleep improvement	- Improving skin ability to retain moisture	- Facilitating milk secretion
- Alleviating physical fatigue	- Improving skin oil content function	- Assisting weigh control
- Enhancing anoxia endurance	- Assisting blood lipids reduction	- Improving child growth
- Irradiation hazard protection function	- Assisting blood sugar reduction	- Improving nutritional anaemia
- Increasing bone density	- Anti-oxidative function	- Regulating gastrointestinal flora
- Assisting liver protection against injury	- Assisting memory improvement	- Facilitating digestion (regularity)
- Alleviating eye fatigue	- Alleviating lead excretion	- Facilitating bowel movement
- Eliminating acne	- Improving throat function	- Protection of gastric mucosa

Japan: Japan has maintained the Foods for Specified Health Uses (FOSHU) health claims system. To date over 1000 food products have been FOSHU registered. In mid-2015 the Japanese Ministry of Health, Labour and Welfare is scheduled to release new legislation that will complement FOSHU to speed up the process and reduce the costs associated with FOSHU registration.

International regulatory knowledge goes beyond accessing regulatory or policy documents, as often it is their interpretation or the bilateral agreements between New Zealand and the export country that would define the possibility of a health claim equivalence. To capture that knowledge, MPI is running an extensive survey through MFAT's network of the regulatory landscape in relevant New Zealand export markets. HVN is following closely the development of the exercise and expect results to come through early 2015.

HVN will -

- Develop considerable expertise in the understanding, complementarity and best practice of food health regulations in key export markets.

FOOD FOR HEALTH RESEARCH ENVIRONMENT

As a mission-led virtual centre of research excellence, HVN must operate collaboratively and effectively with the breadth of research centres, Crown Research Institutes (CRIs), Universities and research organisations of New Zealand. These relationships will need to include those existing research capabilities and aligned funding. HVN will also coordinate international engagement, in accordance with the mission, to achieve additionality and science excellence.

NEW ZEALAND

Mission-led National Science Challenges, including HVN, are new to the NZ research environment. Given the importance of the primary industry sector's significance to New Zealand, existing programmes and research initiatives exist for many of the aspects of the food economy from 'farm & fisheries through to fork'.

HVN is a new mission-led strategic government investment to accelerate the growth in the export returns from the New Zealand F&B sector.

- HVN is not a direct extension of existing Government research contracts and schemes.
- HVN research priorities are based on a new strategic approach and are mission-led.
- HVN will interact dynamically with the network of past and ongoing Government RS&T investment and private sector investment in research. HVN will be relevant for beyond 10 years, with continued collaboration, leveraging and mutual growth of synergies across networks.

National Science Challenges
HVN has synergies with four other National Science Challenges. At the present time all are in varying stages of establishment and Government contracting.

Three of these challenges are specifically focused towards the health of the New Zealand population, including; A Better Start; Healthier Lives; Ageing Well which will investigate many for the same health issues we are focussing on in HVN

Our Land and Water includes a focus on adding value to NZ raw materials and supply chains, although prioritises are yet to be established.

New Zealand Crown Research Institutes
AgResearch and Plant & Food Research (PFR) are Collaboration Partners in HVN.

Substantial CRI Core funding is to be aligned to High Value Nutrition the majority of which is from these Collaboration Partners (details in Appendix 2). In addition there is a small alignment of Core funding from the Institute of Environmental Science and Research (ESR). AgResearch and PFR have identified the aligned Core funding and its current focus. The mechanisms and operational strategies for the future alignment of this CRI Core finding will be established in the implementation of the research plans moving into mid-2015.

New Zealand Universities
Three Universities (University Auckland, Massey University and University of Otago) are High Value Nutrition Collaboration Partners. Within these partners strategic and part-University funded research and education programmes are aligned with High Value Nutrition.

- The **Food and Health Programme** (University of Auckland) is an interdisciplinary research and teaching programme drawing on specialist expertise in food science, process engineering, nutrition, health, social sciences, business and commercialisation from across The University of Auckland.
- **FoodHQ** (hosted by Massey University) is New Zealand's international centre for collaborative food research. FoodHQ is a formal partnership between AgResearch, Fonterra, Massey University, Plant & Food Research and the Riddet Institute. It is supported by the Manawatū District and Palmerston North City councils.
- The **Institute of Food, Nutrition and Human Health** (IFNHH) (Massey University) offers integrated research and education across the entire food and health value chain.
- University of Otago has research, education and translation capabilities in the **Department of Human Nutrition** and **Department of Food Science**.

Research knowledge and capacity in food science, food safety, food marketing and human nutrition also exist in Universities that are not Collaborating Partners. Notable capacities include,

- **The Centre for Food Research and Innovation** (CFRI) (Lincoln University)
- **Food Science Research Centre** (AUT University).

Independent Research Organisations
RS&T organisations include independent research institutes. Aligned and complementary collaborations, including sub-contracted funding extends to these organisations. Those most aligned to the HVN mission include;

- **Malaghan Institute of Medical Research** which targeted research focused on finding cures for cancer, asthma and allergy, arthritis, multiple sclerosis and infectious disease.
- **Cawthron Institute** which undertakes research to protect the environment and support sustainable development of primary industries.
- **Medical Research Institute of New Zealand** is an independent research organisation aimed at the prevention and treatment of diseases with a focus on research to improve clinical management.

Centres of Research Excellence
The Centres of Research Excellence (CoREs) fund administered by the Tertiary Education Commission aims to encourage the excellent tertiary education-based research that is collaborative, strategically focused and creates significant knowledge transfer activities. There are currently four Centres of Research Excellence relevant to HVN. Maurice Wilkins Centre and Brain Research New Zealand have funding commencing 1 January, 2015. Presently, Gravida (The National Centre for Growth and Development) and the Riddet Institute are rebidding to be renewed.

- **Maurice Wilkins Centre** (hosted by the University of Auckland): Molecular biodiscovery in the areas of cancer, diabetes and metabolic disease, infectious disease.
- **Brain Research New Zealand** (co-hosted by the University Auckland and University of Otago): Diseases of the brain, including the use of latest MRI capabilities.
- **Gravida** - The National Centre for Growth and Development (hosted by the University Auckland): Research focus on how conditions encountered in early life affect the way an individual grows and develops throughout life.
- **Riddet Institute (**hosted by Massey University): Research at the intersection of food material science, novel food processing, human nutrition and gastrointestinal biology.

The Food Safety Science and Research Centre
The Food Safety Science and Research Centre aims to promote, coordinate, and deliver food safety science and research for New Zealand, and will therefore be a key partner in food science. HVN is following the creation of the centre that is happening simultaneously to this Challenge and exploring synergies.

Food and beverage industry-led and government-funded research and development
Callaghan Innovation (CI) is a Crown entity (established February 2013) aimed at connecting businesses with research organisations across the innovation system. CI aims to support business innovation and capability. As an advanced technology institute CI has technology laboratories and specialist equipment, in addition to

managing government funding to support business innovation and technology capability. CI are currently developing an overarching strategy for the New Zealand F&B sector which will be an important mechanism for coordinating government support for the sector and will likely influence our approach within HVN.

The HVN challenge (and potential investments) is also acknowledged to be part of the active engagement that **NZ Trade and Enterprise** (NZTE) has with NZ businesses and NZ Inc. partners (also incl. Callaghan Innovation, MPI). Within the NZTE Impact programme, specifically where NZTE is focused on growing a high quality active customer portfolio, NZTE have committed to:

- Ensure visibility throughout NZTE of the HVN programme of work;
- Assist to reduce the cost for businesses engaging with the HVN and the organisations in the HVN network;
- Track HVN investments and 'prepare the market' for the investments made;
- Use the HVN as a source of smart, forward looking businesses who want to work with NZTE to realise international growth.

Primary Growth Partnerships

The Primary Growth Partnerships (PGP) funded programmes are business-led and market-driven innovation programmes that work across the primary industry value chain. Government funding, Ministry of Primary Industries (MPI), is matched by industry co-funding. Current PGP programmes cover many aspects of NZ primary production and manufacture. Of the current 16 funded PGP programmes, several have scope and alignment with HVN. These include:

- **FoodPlus** aims to generate new, higher value products, with a focus on new food, ingredients and healthcare products from the red meat industry.
- **Transforming the Dairy Value Chain** has an embedded theme based on robust human nutrition and health benefits. The aim to deliver health benefits provides the best opportunity to add value to New Zealand's food exports. The targets are maternal and paediatric nutrition, and mobility.
- **Whai Hua** aims to develop immune-enhancing dairy milk products targeting health-conscious consumers in Asian and New Zealand markets.

Ministry of Business Innovation and Employment (MBIE) Sector-Specific Contestable Funded: Contracts Mapped to HVN.

HVN commences activities with significant past (completed) and on-going research in the foods for health area that is supported by contestable funding from MBIE. MBIE has identified aligned research (mapped) contacts (http://www.msi.govt.nz/update-me/major-projects/national-science-challenges/mbie-managed-contracts/).

HVN will –

- Maximise the effectiveness of government research investment within the sphere of crown investments. These relationships extend to the range of funding that is co-funded by industry.

Further Strategic Collaborative Actions and Initiatives

The funding mechanisms identified are only a component of the complexity and vigour of the New Zealand research environment. Notably not included are possible aligned contracts awarded through the Health Research Council (HRC) and the Marsden Fund of New Zealand. These schemes are significant in awarding investigator led research of excellence. HVN has a mission to focus on research excellence, including research that requires stretch. Thus researchers of excellence, with expertise funded from these investigator-led schemes are likely to be critical to the success of HVN.

Achievement of the HVN mission requires the establishment of an authoritative voice on food for health. As such the level of excellence of research required will both be attractive to established and skilled researchers across the disciplines.

INTERNATIONAL

Throughout the world the importance of food production and export earnings has resulted in considerable public funding of research focused on food for health.

The scoping and engagement of HVN in international partnerships will require attention being directed towards the extent to which the international partnership offers new capacities, increases leverage and mission impact. The developed prioritised research programmes have identified researchers and collaborating institutions that can offer some of these advantages.

A more strategic approach is to engage in the exploration and development of funder-aligned initiatives that can gain the support of multiple partners. Possibilities for HVN co-investment with international programmes have been explored both for Europe and also Singapore.

Europe

The European Union (EU) funds an array of investment programmes, including; European Technology Platforms, European Innovation Partnerships and ERAnets that relate to aspects of foods for health. In the midst of these complex schemes, is the Joint Programme Initiatives (JPI). Of these the JPI 'A Healthy Diet for a Healthy Life' (HDHL) is a significant member state funded research facilitation agency. The JPI, on the basis of agreement form the European partners, has launched three Joint Actions that underpin the research areas. These actions have either commenced or are to be finalised by early 2015. Each Joint Action seeks funding proposals from member state scientists. New Zealand, led by MBIE, has commenced discussions on possible collaborative engagement. Important in this is the ongoing development and planning for future Joint Actions that are potentially beneficial for HVN.

Central to the role of the JPI is the impact it has on ERAnet (where EU funding extends that contributed by member states) and the European Commission managed Horizon 20:20 societal challenges. Within this food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bioeconomy may be funded to the sum of 3.85 billion euros, 2014-2020.

North America

There is currently a lack of nationally coordinated food for health research activities in North America. Thus collaborative opportunities with North America remain ad-hoc and dependent upon researcher-to-researcher relationships. New Zealand researchers are eligible to seek NIH funding, although success rates are low and opportunity is limited to unique and world-leading research that cannot be readily replicated within the US. The New Zealand government has small bilateral research grants, none specific to foods for health with North America.

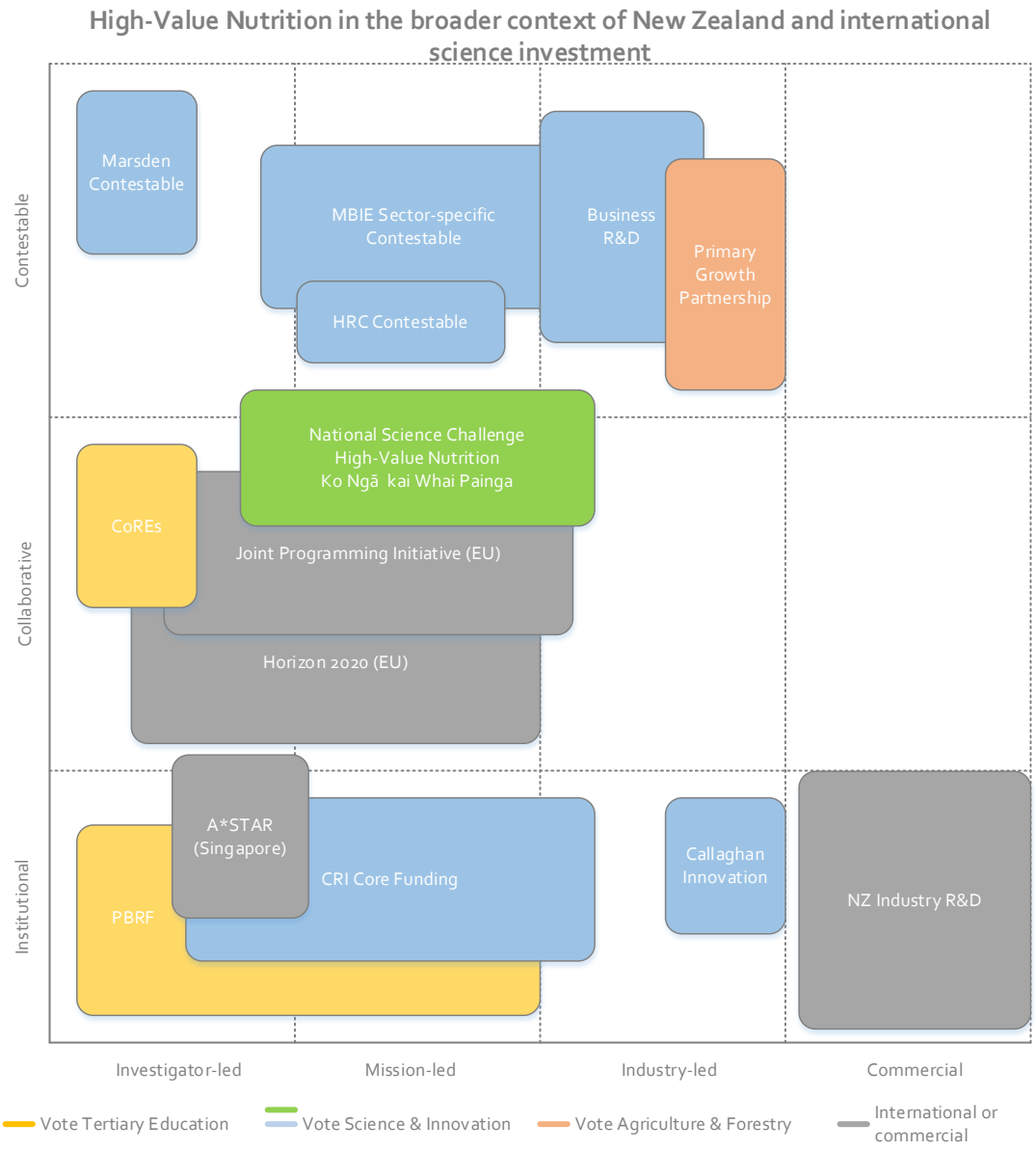


Fig. 3 – HVN's research context. Adapted from the "Draft National Statement of Science Investment".

Asia

Within Asia, bilateral funding (NZ-China, NZ-Japan and NZ-Korea) and the recently announced MBIE-A*STAR (NZ-Singapore) funding in 'Foods for Health' are contributing to shared expertise and the internationalisation of NZ research. The Singaporean funding has achieved matched funding from each country and the success of this initiative may dictate further bilateral investment. Singapore is potentially strategically important for HVN given its closer access to Asian markets and the Singaporean population (4.4 Million) itself.

HVN is -

- Developing a science plan that aims to complement and adapts to the environment to create the dynamism and additionality required to maximise the investment and more effectively deliver against the HVN mission.

RESEARCH PLAN

INVESTING IN RESEARCH FOR IMPACT

The HVN framework for investing in mission-led science

Drawing synergies from this dynamic environment, HVN is to achieve its mission through the involvement and investment of resources significantly beyond the funds available to the Challenge to invest directly. Nevertheless it is those direct investments it makes that defines HVN and creates the conditions for the mission to be achieved. The aim in creating a dedicated research investment framework is to ensure an optimal alignment between the Challenge's mission, strategy and activities.

A 10-YEAR STRATEGY

IT STARTS WITH THE CONSUMER

HVN has developed a strategy centred on food for health consumers. This is a step change from much of the current scientific research and industry activities. The more traditional approach is the analysis of possible bioactivity (often via *invitro* screening) of isolated food ingredients. From the basis of potential bioactivity, ingredients and foods are developed with little knowledge of the consumer's needs and, often, the aim of extending the insights of bioactivity into clinical studies. If clinical relevant effects are shown, application to markets may be developed. Failure rates are high, in part because consumer demand and confidence in the health effect has not yet occurred. Further the pathway to regulatory substantiation is frequently unclear and the steps made to achieve a health claim are uncoordinated. This can be viewed as business as usual and it is unlikely to be an effective mechanism for realising the export revenues required to meet the government's expectations.

HVN Goal
Identifying food for health opportunities through greater consumer insight.

HVN is -

- Aiming to generate the insight and knowledge required to understand the drives and needs of consumers in our major export markets.
- Defining relevant health food targets, based on both consumer insights of perceived health concerns and evidence of the physiological deficit underlying that health concern.

THE SCIENCE EXCELLENCE: CREATING OPPORTUNITY FROM NEW KNOWLEDGE

The current understanding of food-health relationships is a major limiting factor for industry to successfully develop efficacious food solutions for consumer health needs. The required investment to fill these knowledge gaps is potentially both substantial and importantly requires the coordinated attention of multi-disciplinary and sustained research programmes. It is therefore an area that is not extensively covered by industry R&D due to the risks and the difficulty in capturing all the benefits by one firm, and is therefore aligned with the pre-competitive nature of government investment in research (i.e. to address market failure).

Consumer-led health concerns may not be readily met by existing knowledge of the biological determinants and the mechanisms by which foods may impact on these biological pathways. This is a central aspect in the development of efficacious food solutions for consumer health needs, and a factor limiting industry-led investment.

Understanding the biological determinants of a consumer-led health concern requires the identification of the causative mechanisms. Subsequent to this is the ability to measure changes in either these causal mechanisms or factors that are significantly aligned to them. These factors are biomarkers. A biomarker can be defined

biologically, as a predictor or measure of change in health status. Additionally, biomarkers can be used to create the awareness, motivation and activation of a consumer target. An example is cholesterol, which is both a biological factor implicated in heart disease, but additionally has become a motivator of consumer behavior and purchases (eg via the role of added plant sterols in margarine spreads). One further element of biomarkers is their ability to inform on the effect of an F&B intervention and be used as a proxy of change in health status. The veracity of the relationship between a biomarker and the disease/health status becomes important for food-health claim substantiation.

HVN Goal
Undertake research of international excellence that identifies the key mechanisms and associated biomarkers that generates new opportunities for food-health benefits

HVN has –

- Prioritised commencement of research investment toward programmes that have the specificity, expertise and capability to identify and validate causal mechanisms and biomarkers recognised by food-health regulators.

EFFICIENT CLINICAL VALIDATION

The analysis and measurement of health benefit in response to a F&B product requires two key elements. The first is ensuring that the food has the functional integrity and compositional characteristics to deliver the health benefit. Thus it becomes important that integrated knowledge flows from an improved understanding of the causative mechanisms of health loss/health gain to the food industry that can effectively generate products targeting the biological insights. The 'science of food' is critical in ensuring there is the right preparation, processing and formulation to deliver the sum total benefit required from the food. The understanding of what food science to apply to what health question will require integration and a stepwise relationship between the clinical research, the foods and the food scientists.

The second key feature of clinical validation is the robustness of the clinical trial interventions. The FSANZ legislative processes will require companies lodging dossiers to be aware of the quality of the clinical validation studies. High-quality clinical trials that have undergone peer-review and conform to the best standards of management and data analysis will be required.

HVN Goal
To link the science of food and clinical trial practice and management accelerating the validation of food-health relationships.

HVN will –

- Invest in food for health research that aligns with clinical and biomarker insights to fast-track the opportunities to develop foods that can maximize health benefits
- Be committed as the 10 year strategy progresses to develop standards, protocols and agreed principles upon which the regulator can be reassured that the standards of analysis are robust, high-quality and applicable to the consumer market.
- Utilise food science, including food processing and food structural knowledge to generate novel food prototypes for clinical validation of health benefits.

PRODUCT DEVELOPMENT

The final step in the pathway from combined consumer insight and clinical validation is the transfer of this knowledge with the New Zealand F&B industry. This will include the continued food science necessary to fine-tune and identify production ready food concepts. To further accelerate and de-risk the pipeline towards the launch of a proprietary F&B product, HVN regulatory and clinical trial insight can guide the pathway towards a food-health claim submission.

HVN Goal
To combine consumer insights with research knowledge of clinical benefit (including biomarkers), and the science of food to create a significant proposition for New Zealand F&B industry uptake and benefit.

HVN will –

- Sustain ongoing consumer insight analysis in areas of industry alignment.

- Develop clinical science and analytical capabilities (including biomarkers) to undertake target consumer analysis
- Focus the science of food research to solve the technical challenges of creating a high-quality and consumer ready product.
- Facilitate knowledge transfer and uptake.

By placing the needs of consumers in New Zealand's export markets at the centre of the research programme, HVN is taking commercial opportunities as the line of sight that will guide its research and ensure the Challenge is focussed on its economic mission. Interactions with F&B businesses to date indicate a strong support for this consumer-centric strategy.

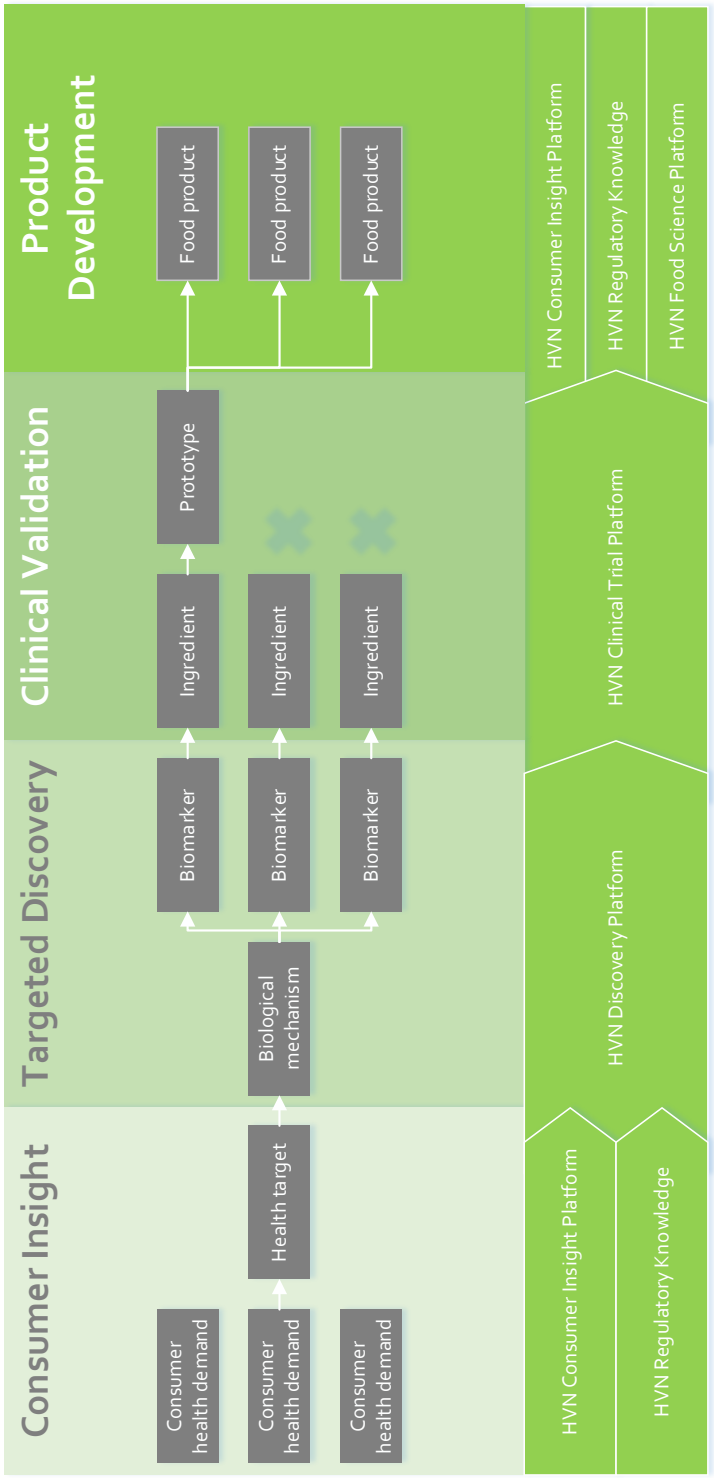


Fig. 4 - Diagrammatic representation of HVN's research pathway

A STRUCTURED INVESTMENT

Two main categories have been defined as part of HVN's direct research investment:

1. **Priority Research Investment,** which result from HVN's foresight research planning process lead by the Directorate and Science Leadership Team, and involving a wide group of experts from across New Zealand. This is the core of HVN research investment and 50% of available funds will be committed to it, over the two funding periods (2015/2019 and 2019/2024). The nature of these priority investments will change over the two periods, with the first period focussing on building capabilities likely to be useful to industry and the second period directed more towards the translation and use of those capabilities in achieving the mission.

2. HVN is also to commit between 23 and 26% of the available funding to ensure adequate refresh and adaptability of the Challenge over time via **contestable funding** open to all New Zealand researchers. The focus of that pool of funding will be on:
    - New ideas (focus on novelty via an open call)
    - New researchers (which could focus on postdoctoral researchers)
    - Strategic gaps not covered by the Priority Research programmes (i.e. a defined call)
    - Industry co-funded collaborations
    - International science collaborations
    - Māori business oriented projects
    - Research capacity building (could be same as new researchers above)
    - Māori researcher capability/capacity building

HVN will also hold funds aside for both defined "**Special Projects"** and **"Contingencies".** This will include responding to time-bound opportunities and fund activities that are essential to achieving the mission. This may also include the funding of activities necessary for the mission, but not necessarily research focused (e.g. regulatory activities, validating the relationship between research and export returns, reviewing existing knowledge, industry opportunity exploration, etc.).

The purpose and role of each investment pools and detailed budget is presented in Appendix 1.

Table 6 - HVN high level budget

	2015/2019	2019/2024
Contestable Research Investment	$ 7.0m	$ 14.0m
Priority Research Investment	$ 14.5m	$ 26.5m
Special Projects	$ 1.5m	$2.0m
Contingency	$ 0.95m	$ 2.5m
Governance / Advisory	$0.37m	$0.45m
Communications / Regulatory	$1.24m	$1.75m
Industry Liaison / Commercialisation	$0.675m	$0.9m
Science Leadership	$2.74m	$3.5m
Head Office / Administration	$1.0m	$1.4m
TOTAL	**$30.0m**	**$53M**

Note: these are rounded numbers. The 2015/2019 period is likely to be a little over 4 years while the 2019/2024 period is a full 5 years.

POSITIONING HIGH VALUE NUTRITION STRATEGICALLY

To best develop a programme that will honour government policy objectives, the HVN strategic objectives, and external real-world factors, HVN is following a portfolio approach to research investment, with the following goals:

- Allocate resources to maximise impact and build a lasting research capability of international standing
- Achieve a balanced prioritised profile that best honours constraints and drivers;
- Integrate efforts towards better achieving the HVN mission.

The two main dimensions articulating that portfolio and best reflecting the intent of the New Zealand government in creating this Challenge are Science Stretch and Impact. These dimensions underpin the assessment, prioritisation and positioning of HVN's science.

IMPACT

The likely potential economic outcomes (increased export revenues) from the successful uptake of research by the Food and Beverage sector to create and market products with scientifically validated health and wellbeing benefits for consumers.

SCIENCE STRETCH

A combination of science excellence, with additionality (including collaboration, integration across themes and disciplines) and scope that is beyond 'business as usual'.

In terms of positioning, the risk profile of the HVN research investments needs to be put in perspective with the existing broader food for health research investments from government and industry and ensure it avoids business as usual. Current industry co-investments are mostly closer to market, with limited science stretch because of the risk involved. Other government funded research (e.g. MBIE contracts mapped to HVN and aligned CRI core funding as well as other MBIE funded research) is more narrowly focused through smaller scale projects, hence generally expecting lower impact through lower science stretch.

In that context HVN is positioning its research as having the potential for medium to high impact and with medium to high science stretch. In positioning itself at the higher end of the risk profile HVN is both complementary to and extending the broader NZ research investment in food for health. The intention in taking this higher risk position is to create a step change in the competitiveness of the New Zealand Food and Beverage industry based on lifting the quality of science validation of food health relationships and their regulatory approval.

Table 7 - Strategic positioning of High-Value Nutrition

High Impact / Low Science Stretch This area of research investment represents for businesses a more acceptable level risk for the rewards, and is therefore covered by the R&D of large industry players (e.g. R&D on high calcium products bones for Fonterra's Anlene product) or industry-led research (e.g. PGP "Transforming the Dairy Value Chain").	**High Impact / High Science Stretch** High-Value Nutrition is positioning its research portfolio in this quadrant.
Low Impact / Low Science Stretch This area tends to cover short term product-specific research and is generally addressed by R&D from medium-size businesses and/or fee-for-service research.	**Low Impact / High Science Stretch** Research in this area have high risks for minimal rewards, and therefore generally not worthy for investment. (Note: there is likely to be investments in this category from Blue Skies funds such as Marsden with the potential for serendipitous findings with potential for impact)

HVN has developed criteria that separately allow the review of potential impact and science stretch (Appendix 4) when assessing and ranking research investment options. This enabled HVN to select investment options that would construct the intended high-impact/high-science-stretch portfolio.

HVN has also developed a set of strong investment principles that guided the development of the investment framework and its execution.

INVESTMENT PRINCIPLES

- **Mission- and impact-orientated** – the investment decisions will be aligned and sized to the overall objective of the NSC and HVN's strategic targets, and driven by the impact they have on the New Zealand F&B industry.
- **Excellence in research and management –** the investment will include international and national review (including industry) with diligent financial accountability and processes.
- **Encouraging collaborative behaviours** – the investment framework will support productive collaborative behaviours across research groups and disciplines and across research and industry. This includes building trust among researchers, stakeholders and shareholder, and encouraging full engagement to orient research towards outcomes and impact.
- **Transparent** – research areas will be evaluated on a set of criteria that will be effectively communicated to all stakeholders.
- **Environment awareness and flexibility** – the process will be able to adapt the research investment and respond to scientific, political, market and economic changes.
- **Monitoring** – the portfolio will be actively managed and evaluated using a series of metrics (Inc. KPIs) to ensure investments are outcome focused and directed towards impacts, and in support of HVN's mission.

LIFTING THE VISION THROUGH PLANNING

To create a research programme that is worthy of its status as a National Science Challenge, HVN purposefully consulted widely and drew upon the expertise from across a wide range of research providers, following a coordinated and structured planning process.

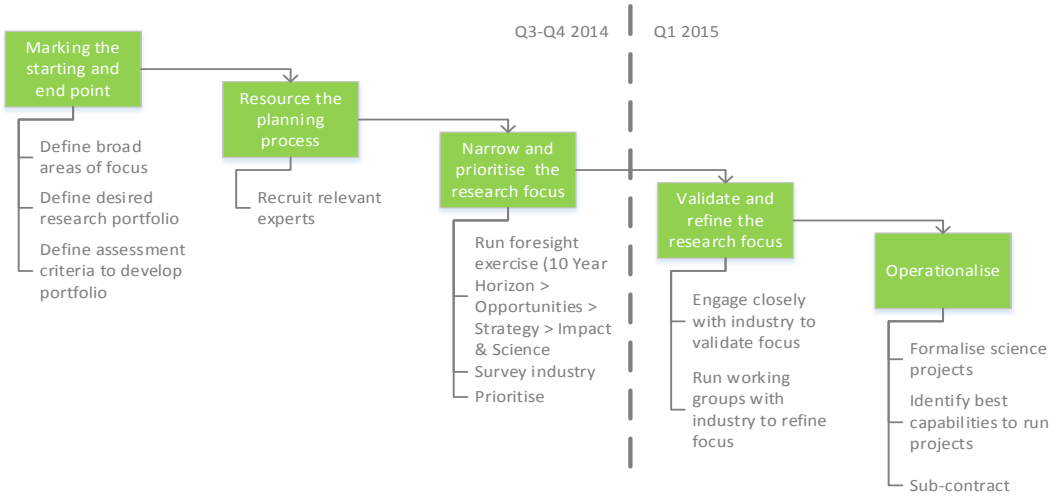


Fig. 5 – High-level planning steps

1. **Marking the starting and end point** - Define broad areas of focus, the priority health targets, that are relevant to consumers, NZ industry and science capability. This defines the basis from which HVN's focus is narrowed. Then define and articulate the high–level characteristics of HVN's targeted portfolio of research, and the key criteria to evaluate research against and reflect those desired characteristics.
2. **Resource the planning process** - Bring together the best and complementary New Zealand experts with the desired and broad skill sets to run the planning and bring novel approaches to food for health research.
3. **Narrow and prioritise the research focus** - Narrow the focus of HVN's research by identifying specific consumer needs (foresight exercise) within each priority health targets that the research can potentially focus on and form the basis of research options to be prioritised. Ensure the relevance, quality and worthiness of the research options through direct feedback from industry businesses, Industry Advisory Panel feedback, Science Advisory Panel feedback, HVN Board feedback, MBIE feedback and prioritisation of research options against criteria.
4. **Validate and refine the research focus (Q1 2015)** – Validate the opportunities by closely engaging with New Zealand F&B industry. Further refine the research focus by running working groups that bring together scientific experts and industry.
5. **Operationalise (Q1 2015)** – Bring the science plan to "contract ready" stage, through formalising the science projects, identifying the New Zealand and international capabilities that can best achieve it, before initiating the sub-contracting process.

To lift the vision of the Challenge while narrowing the focus of its research, HVN has embedded foresight in its planning process, seeking to anticipate future developments and needs in a long-term timeframe. Foresight is commonly defined as a systematic, participatory, future intelligence-gathering and medium-to-long-term vision-building process aimed at present-day decisions. Applied in the context of HVN foresight provides a powerful tool to anticipate food-for-health consumer trends and consequently identify the potential opportunities that are relevant to the NZ industry.

HVN's approach to foresight

1. **10 year Horizon** – The aim is to define what the environment of food for health will be in ten years' time. This is to be achieved by scanning the horizon, harvesting relevant information, identifying the drivers that influence that environment and drawing conclusions on what the 10 horizon could therefore look like. This future scan must also encompass the current state of knowledge, science and industry engagement (baseline analysis).
2. **Opportunities** - The aim is then to identify, characterise and rank opportunities in that 10 year horizon for the NZ F&B industry to capture increased economic returns through foods with validated health benefits. Gaps of knowledge and assumptions are also referenced to feed the planning (i.e. potentially develop consumer insight study to fill the gap). Opportunities are prioritised against impact criterion.
3. **Strategy** – The aim is to define the goals HVN needs to achieve to seize the opportunities. These high level goals will guide the development of the science plans.
4. **Impact & Science** – Finally the aim is to define the detailed sequence of science targets, and articulate science plans to reach the goals. Then define the pathways to impact and stage-gate for performance monitoring.

ENSURING ALIGNMENT WITH NEW ZEALAND F&B INDUSTRY

Industry engagement is critical to the Challenge's activities, and HVN is ensuring that its research is aligned with the commercial world through:

- Engaging early and continuously during the planning process with its Industry Advisory Panel.
- Defining its focus through the identification of consumer needs, thus creating a line of sight between commercial opportunities and HVN's research.
- Analysing the opportunities against the New Zealand industry capability (Appendix 5);
- Surveying New Zealand F&B businesses to ensure relevance of HVN's focus (Appendix 6);
- Engaging closely to refine the research focus through further validating the opportunities and establishing working groups between industry and experts to formalise science plan (starting Q1 2015).
- Sourcing consumer insight and running dedicated studies that validate the consumer needs and therefore the commercial opportunities (starting 2015).

FUTURE STEPS

High-Value Nutrition has strategically narrowed down its focus of prioritised research investment. This provides the basis to engage purposefully and effectively with the New Zealand F&B industry to deliver a contract ready science plan in the first quarter of 2015. The following activities are in progress and planning.

Dec 2014	Contact the organisations present at the Stakeholder forum that signalled willingness to engage and confirm their interest in participating in further development of our plan in Q1 2015.
Jan 2015	Establish and distribute a survey of NZ business strategies and plans with regards to food for health to inform our activities and the activities of the Food & Beverage Exporters Network (FBEN).
Feb 2015	Initiate one on one HVN/key businesses meetings to discuss their strategies and potential interest in working with HVN.
	Set up working groups for Expert Panels/SLT to engage with key businesses.
	Identify specific interests of Maori F&B businesses in engaging with HVN and bring into the planning process.

Mar 2015	Use results of survey and discussion to refine science plans and their prioritisation prior to investment. Following refinement of Priority Research programmes and their focus with industry input work with teams to ensure they are subcontract ready with clearly defined and mission specific objectives and milestones. Hold HVN Board meeting to review progress and ensure planning is advance to allow a rapid start if awarded a second CPA.

HIGH-VALUE NUTRITION ROADMAP

The way forward for coordinated and harmonised research activities

FORESIGHT OUTCOMES

The long-term economic mission of the Challenge dictates that for it to be relevant, HVN needs to anticipate the consumer wants and trends that will be contemporary in 10 years' time. Foresight planning focused on this 10+ year horizon was conducted. Six different Expert Panels (Chair SLT member and science experts) each conducted foresight planning, with a representative of the consumer insights expert panel in all sessions. The result of the foresight activities identified the complex health opportunities that underpin potential consumer led demand for foods with validated health benefits. There were many potential opportunities identified.

The New Zealand Food & Beverage Information Project (lead by MBIE) has identified that increased export sales from Asian countries is potentially a sustained trend for the New Zealand F&B sectors. On that basis, increased consideration was given to the Asian markets in scanning and identifying food-for-health opportunities.

10 YEAR HORIZON - THE CONSUMER HEALTH AND POPULATION MEGATRENDS

The Expert Panels identified a number of major and sustained consumer health megatrends and population demographic changes of relevance to the HVN mission.

Asian Economic and Population Growth

Expert Panels considered that New Zealand exports have shifted from a traditional European focus on the supply of dairy and meat products towards a diversification and supply of F&B products into Asian markets. The rapid growth over the last decade of Asian F&B sales has corresponded with increased market access and the rapid economic transformation of these economies, including urbanisation and increased per capita GDP driving a strong consumer demand. Asia has increased food imports over the past 25 years, and New Zealand sits in a privileged position at the "doorstep" of Asia. The foresight conclusions by the Expert Panels also drew upon NZ government data indicating that this is likely to be a sustained trend for NZ F&B exports.

Asian countries are experiencing a rapid economic development and urbanisation. These changes are impact on food choices that are increasingly changing from a traditional diet to one incorporating ingredients and products that are more typically found in a westernised dietary pattern.

The New Zealand Food & Beverage Information Project has identified that this is potentially a sustained trend for the New Zealand F&B sectors. On that basis, increased consideration was given to the Asian markets in scanning and identifying food-for-health opportunities.

Ageing population

The "greying" of society is a demographic reality and a major global food market opportunity was identified. The proportion of the Asian population over the age of 50 years is predicted to rise from 20% to 40% by 2030. People over 50 account for at least one half of the F&B market in China, hence there is the expectation for continued growth of F&B with health benefits

Ageing impacts on many aspects of health and wellbeing. Considered significant amongst these is the changing function of the gastrointestinal tract, immune function and mobility that were likely to influence consumer's food for health requirements.

Population weight gain

Overweight and obesity has reached epidemic levels in most developed and many developing nations. The rising population weight gain was identified as having affected Asia significantly in the past decade. Consumer demands for weight-control and slimming products in the functional foods market remains high.

Accompanying weight gain is the escalating risk of cardio-metabolic diseases, particularly type 2 diabetes and cardiovascular disease. The greater adverse metabolic health risks than Caucasian populations, was identified to likely influence consumer health and wellness requirements.

The Nurtured Generation

The importance of declining fertility rates was evaluated. Urbanisation, higher levels of education, employment and societal demands the age of first time mothers is increasing. The delay in having a first child is also accompanied by a reduction in the total number of children. China, as an example, through strict population control has had a mandated one child policy (since 1979). Relaxed in November 2013, nowallowing families to have two children, if one parent is an only child, the expert panels concluded that family sizes would remain small.

Fewer children, born to older and wealthier parents, with increased standards of education were foresighted to impact on parent foods for health demands. Parental expectations of the health and cognitive development of their children has increased, driven in part by the perceived importance of early education for future career success. As a consequence an increased and sustained demand demands for F&B of benefit to the health and development of the child is anticipated.

FOOD-FOR-HEALTH OPPORTUNITIES IDENTIFIED

Out of this landscape foresight of the 10 year horizon and the consumer mega-trends that will be relevant for New Zealand exporting F&B industries, the expert panels further engaged in strategic analysis to refined the potential areas of high impact and high science stretch research investment. The possible areas of research were defined as Opportunities. Each opportunity was a substantial possible programme of research that had the potential to satisfy each of the following points:

- Has the potential for economic impact (i.e. is mission led);
- Required science investigation worthy of this Challenge (i.e. is also science led);
- Was aligned with New Zealand's industry.

The Expert Panels identified 18 consumer-led opportunities that met those conditions, and were entered in the Challenge's prioritisation process. These are listed in Appendix 7.

ALIGNMENT WITH F&B INDUSTRY PRIORITIES

HVN surveyed 40 NZ industry representatives (see Appendix 6) to ensure relevance of its strategic direction.

Remarkably from the data received from the industry representatives was identical for each health target, although data differed between respondents. The proposed areas of research were reported to be of equal relevant to NZ businesses' commercial strategies (Fig. 6).

Across the surveyed business, more were willing to engage directly in working groups on Gut and Immune Health and Metabolic Health (Fig. 7). Those two areas are strongly represented in the prioritised opportunities.

More tellingly, 69% rated as probable a financial investment in HVN research, with on only 7% ruling it out at this stage.

Fig. 6 – How relevant are the following emerging priorities to your commercial strategy?

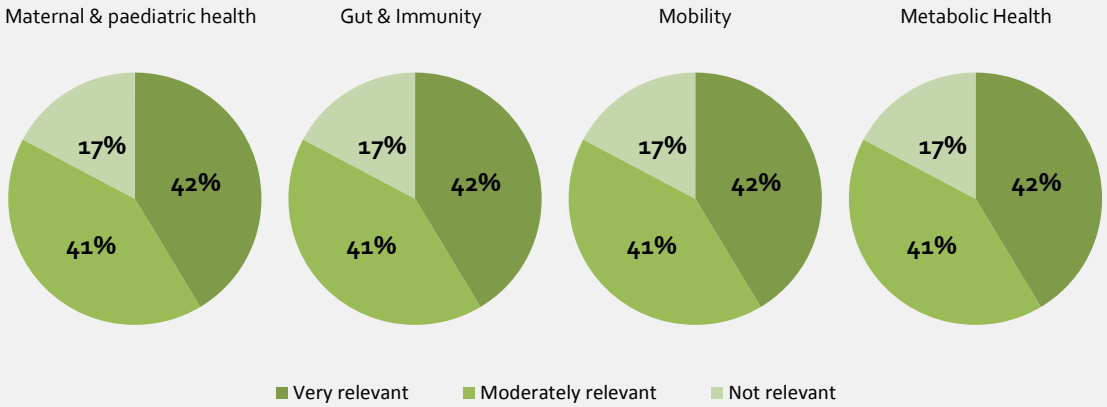
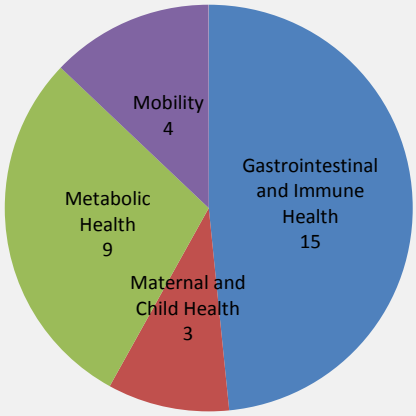


Fig. 7 - Which, if any, of the emerging priorities would you be willing to join a working group on? (count of businesses)



ALIGNMENT WITH F&B INDUSTRY GROWTH

The Coriolis report "*What does Asia want for dinner*" identified which F&B product categories have growth potential in Asia. This report also evaluated which NZ industries have growth capacity to be able to meet these demands. The Coriolis' analysis concludes that produce, meat and dairy are areas of growth potential, with processed food and beverages as being areas of strong NZ industry growth capacity. As detailed in Appendix 5 and summarised in Fig.8, the prioritised research programmes are aligned with these findings.

Category	OVERALL	New Zealand			E/SE Asian markets				HVN opportunities applicable to category			
		Positive production or input metrics	Capable of strong produc-tion growth	Fit with NZ core compe-tencies	Growing Asia imports from peers	Potential for value added	Country of origin important	Key compe-titors have high costs (vs. NZ)	"Room to grow" in the market	Gastro. Tract Funct. & Comfort	Building Immune Defences	Early Life Immune Tolerance	Peak Nutrition for Metabolic Health
Dairy	●	●	●	●	●	●	●	●	○	●	●	●	●
Meat	●	○	○	●	●	●	◐	○	●	●	●	●	◐
Seafood	○	○	○	◐	○	◐	○	○	◐	●	●	●	◐
Produce	●	●	●	●	●	●	◐	○	◐	●	●	●	●
Grains	○	○	○	○	◐	○	○	○	○	●	●	●	◐
Oilseeds	○	○	○	○		○	○	○	○	●	●	●	○
Other	○	○	○	○	◐	○	○	○	○	●	●	●	○
Processed	●	●	●	◐	●	●	◐	◐	●	●	●	●	●
Beverages	●	●	●	◐	●	●	●	●	●	●	○	◐	○

Adapted from WHAT DOES ASIA WANT FOR DINNER? Emerging Market Opportunities for New Zealand food & beverages in East & South East Asia potential. July 2014; v1.00 The Food & Beverage Information Project. MBIE, NZ. Greater shading indicated greater opportunity.

Fig. 8 – Qualitative scorecard of HVN Prioritised Research Opportunities, together with NZ F&B export opportunities to Asia.

PRIORITISATION OF OPPORTUNITIES

The insights generated by the Expert Panels were extensive. This demonstrates the breadth and depth of possible research opportunities (Some 18 discrete opportunities were identified – see full list in Appendix 7). Prioritisation of HVN investment was addressed with the analysis against the indicators of impact and science stretch. Analysis of these indicators was performed by the SLT and Directorate. The outcome is shown diagrammatically below.

Given that the strategic positioning of this challenge is towards research identified as of high impact and high science stretch, the subset of Opportunities were identified on the basis of potentially greatest Impact and Science Stretch were considered for further analysis.

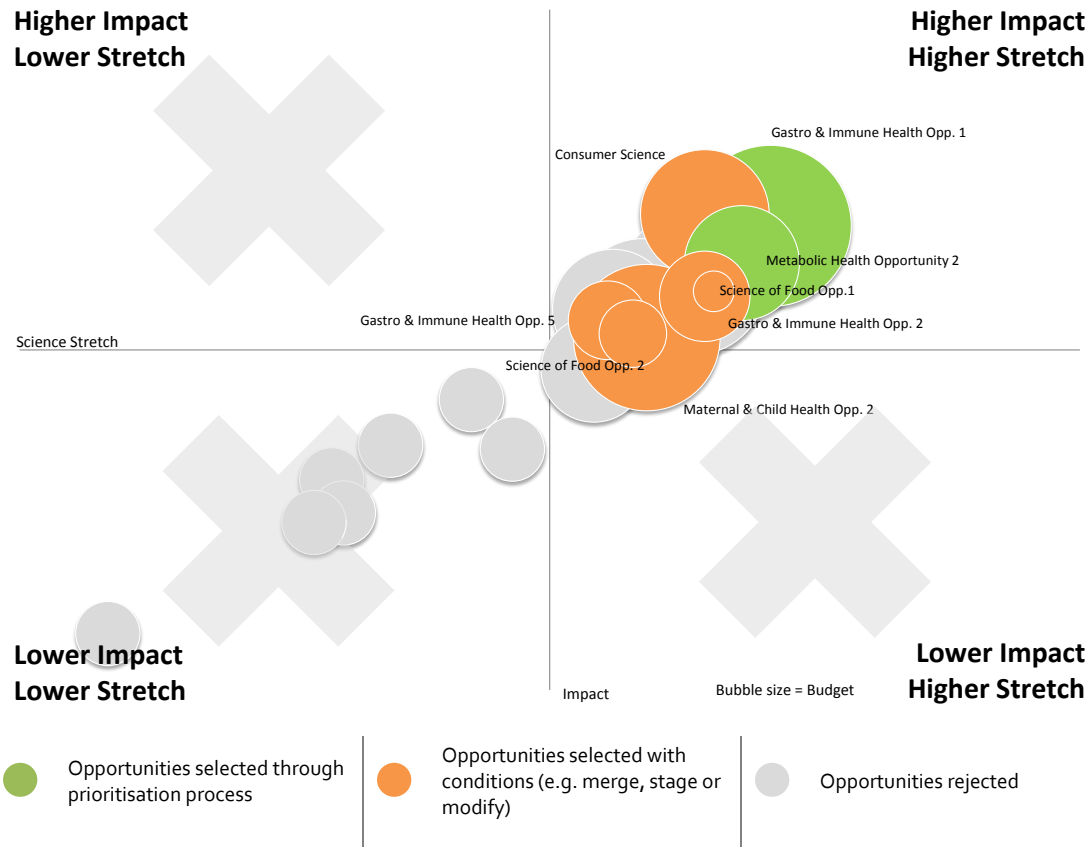


Fig. 9 – Portfolio development. Opportunities assessed against the Science Stretch and Impact dimensions

Further refinement and prioritisation within those Opportunities identified included;

- Feedback from the chair of the MBIE Assessment Panel;
- Feedback from members of the Science Advisory Panel;
- Feedback from the Industry Advisory Panel.
- HVN Board approval.

THE PRIORITISED RESEARCH

The prioritised research strategy includes five identified major programmes of research. These have been structured to generate synergies and are articulated around common platforms. These platform activities include proteomics, metabolomics, epigenetics and microbiome analysis.

Table 8 – Prioritised research

Health targets	Prioritised Opportunities	Description
1. Consumer Insights	**2015-2016**	Objective 1 – Consumer insights - Scanning the horizon
	2016-2018	Objective 2 – Product focused consumer insight
2. Science of Food	**2015-2016**	Objective 1 – Food Science – Scanning the horizon
	2016- 2018	Objective 2 – Bioactive food systems
3. Metabolic Health	**Peak Nutrition for Metabolic Health** **2015-2019**	Objective 1 – Characterising the pre-diabetes phenotype Objective 2 – Characterising metabolic health and diabetes risk
	2019- 2024	Objective 3 – Consumer awareness/activation – toolbox development
4. Gut and Immune Health	**Gastrointestinal Tract Functions and Comfort** **2015-2019**	Objective 1 – Advance the diagnostic predictability of IBS phenotypes Objective 2 – Verifying the causative effects of microbiota on GIT function and comfort
	Building Immune Defences **2015 - 2019**	Objective 1 – Host-microbiota targets to build immune defences Objective 2 – Mechanisms of pollution exacerbated respiratory inflammation
	2019-2023	Objective 3 – Pilot clinical studies of beneficial foods Objective 4 – Application of platform capabilities to new mechanisms of gut/immune function.
5. Weaning Foods for Health	**Early Life Immune Tolerance** **2016-2019**	Objective 1 – Immune maturation Objective 2 – Microbiota and allergy management

Excluded from prioritised investment prior to 2019 was Mobility. Despite the evidence of importance to the NZ F&B industry, the Mobility Expert Panel were unable to generate Opportunities that were sufficiently refined or defined to score well in terms of Impact and Science Stretch. This does not preclude Mobility research from Contestable funding from mid-2015 or being an area of prioritisation in 2019.

PRIORITISED RESEARCH PROGRAMMES

1. CONSUMER INSIGHTS

BACKGROUND

Consumer insights are needed to help guide and prioritise opportunities within and between the HVN Health Domains[1,2]. These insights will be delivered through targeted projects to address identified needs. They will also fulfil HVN's aspiration to collect insights that allow grounding of product-specific information in a broader understanding of the beliefs, attitudes, behaviours and lifestyles of Asian consumers that affect their choices of HVN foods and beverages (F&B). Use of these insights will guide development and help improve the success rate of HVN product launches into Asia; and also prevent significant economic losses associated with development and marketing of new products that subsequently fail in the marketplace.
To achieve these goals:

- Consumer insights from the literature will be merged with pre-competitive knowledge available from NZ F&B companies, NZ Trade & Enterprise, Callahan Institute, Ministry for Primary Industry and Asian academic organisations with a focus on food and health to provide early guidance and prioritisation of HVN opportunities (Year 1).
- Targeted research projects that arise as identified needs from the Health Domains, and are approved by the Science Leadership Team, will explore the consumer beliefs, attitudes, understandings, behaviours and lifestyles that affect Asian consumers' choices relating to specific HVN opportunities (Year 2 onwards).

Initially China, as a single exemplar country, will be the focus of the empirical research. China represents many different market segments, including those associated with different Tier cities and segments of consumers who have different disposable incomes, and who respond in different ways to food[3,4] and health[5]. Emphasis will be placed on those Chinese consumer segments that represent common industry targets in many countries.

The Chinese population is affected by lifestyle diseases associated with increasing affluence and aging to the same extent as the rest of the world[6-9], and sales of health foods are increasing. Packaged functional foods were valued at US$24.6B in 2012, and are forecast to grow[10]. China is an important consumer science target because it is very different from western societies[4]. Their unique perspective is driven by the importance of the collective[11]; Confucian principles[12-14]; Chinese Traditional Medicine[15,16]; the importance of nuclear family units with strong links with the paternal grandparents[17]; male children being more highly valued[18]; grandparents' involvement in childcare[17,19] and the unique demography created by the 'one child' policy. Furthermore, significant social changes are occurring in this rapidly maturing consumption market as rural populations migrate into cities, resulting in changes to individual and family wealth and the altering of traditional family structures - influencing provisioning and preparation of food, increasing access to snack foods and fast food chains, and improving consumer access to information on food and health[3,4,6,20], together with increased exposure to western media and consumption patterns.

SCIENCE RATIONALE

We have clear evidence for economic opportunities arising in the health domains: from trends in product category growth; increasing incidence of lifestyle diseases associated with affluence and aging; existence of categories of consumers who express high interest in healthy foods[5]; and some product-specific Asian research that identified particular barriers to uptake of this type of product, such as a lack of trust in government and food companies[21]. However, much of the supporting information on consumer beliefs, attitudes and

perceptions leading to consumer choice of HVN-style foods has come from research in the west[22-25] – with little equivalent Asia specific data being freely available.

NZ companies have their own private consumer insights that provide them with a competitive advantage, but there is an important role for generic, commercially focused, consumer research to underpin the NZ F&B sector. The new insights we will generate into Asian consumers will form the basis for more targeted, product-specific research by F&B companies. **Objective 1: Consumer Insights – Scanning the Horizon** will build this base knowledge by accessing pre-competitive consumer insights and company market understanding as a way to fast-track HVN's understanding of existing information. There is already support in the industry for this approach (e.g. Comvita). **Objective 2: Product Focused Consumer Insights** is then to extend this research in new directions using innovative, multi-method approaches to generate useful information to help guide prioritisation of health targets and product development, while including industry partners in the research programme.

RESEARCH PROGRAMME

THE RESEARCH TEAM

P.I.: **Dr Roger Harker** (Sensory and Consumer Research, Plant & Food Research)
A.I.s: **Dr Sara Jaeger** (Sensory and Consumer Research, Plant & Food Research); **Dr Denise Conroy** (Senior Lecturer, University of Auckland); **Dr Bill Kaye-Blake** (Pricewaterhouse Coopers/Lincoln University); **Prof. Phil Bremer** (University of Otago).

GOAL

To develop needed Asian consumer insights and cultural understanding of eating habits as they relate to HVN.

RESEARCH PLAN (FROM MID-2015 TO END-2018)

Objective 1: Consumer Insights – Scanning the Horizon
Insights from extant literature have been merged with existing pre-competitive knowledge of Asian consumers from NZ F&B companies, NZ Trade & Enterprise, Callahan Institute, Ministry for Primary Industry and Asian academic organisations with a focus on food and health, and combined to guide early decisions in Health Domains.

- **Milestone 1:** Gain agreement and sign-off on confidentiality agreements with relevant organisations and companies by July 2015.
- **Milestone 2:** Stakeholder interviews and surveys completed by December 2015.
- **Milestone 3:** Report on consumer insights submitted to SLT by April 2016.

Objective 2: Product Focused Consumer Insights
Insights on the beliefs, attitudes, behaviours and lifestyles of Asian consumers' that affect their choice of HVN-style foods and beverages have been "quantified" and specific product targets for development have been identified.

- **Milestone 1:** Research Question 1 (arising as a theme across multiple Health Domains or specific set of issues from a single Health Domain; represents science stretch and will be approved by the SLT) – consumer insights and relevance to HVN reported to SLT and a workshop has been held for HVN participants and industry (2016).
- **Milestone 2:** Research Question 2 – consumer insights and relevance to HVN reported to SLT and a workshop has been held for HVN participants and industry (2017).
- **Milestone 3:** Research Question 3 – consumer insights and relevance to HVN reported to SLT and a workshop has been held for HVN participants and industry (2018).

RESEARCH METHODOLOGIES

Following Objective 1's review, a detailed research plan will be developed to ensure business relevance and scientific integrity (Objective 2). Three criteria will guide methodology decisions: (1) generation of culturally relevant data[26,27]; (2) use of multi-method strategies combining primary and secondary research, using standard and emerging methods based on theoretical perspectives of how consumers make food/beverage

purchase/consumption decisions[28-41]; and (3) epistemological modest disposition, recognising the importance of quantitative analysis, but understanding that it reveals only part of the truth[42]. Milestones will equitably draw upon research capabilities/diversity of methodologies available in the team and their collaborators, and provide 'additionality' not possible within a single NZ organisation.

RESEARCH OUTCOMES

The delivery of consumer insights that help guide and prioritise opportunities within and between the Health Domains; build a consumer-savvy decision-making "skill set" among scientists within the Health Themes; and provide information that allows transparent conversations with industry on product-specific opportunities.

2019-2024 RESEARCH PLAN

Based on the findings from Years 1-4 and the up-to-date literature insight, a framework will be developed of key consumer principles that inform, articulate and validate opportunities for HVN-style foods and beverages for Chinese consumers. As this research is developed, the findings will be integrated directly into the Health Themes to ensure specific pre-commercial product targets and product formats are appropriately assessed through stage-gating. Alongside this product-specific support to the Health Themes, the consumer insights will explore the relevance of the Chinese consumer framework to other major export markets including India, Indonesia and Malaysia.

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2. SCIENCE OF FOOD

BACKGROUND

Strategic scientific guidance on food systems is vital if HVN is to identify research avenues where there is freedom to operate as well as high scientific and technological feasibility and ultimately the potential for economic impact. Objective 1: Food Science - Scanning the Horizon will canvas 'food for health' developments in the scientific, patent and regulatory literature. Food for health regulations in China will receive special attention, and we will interface with the MPI/MFAT survey of key export markets (report due early 2015). Crucially, that mass of highly scientific and technical information will be interpreted for non-food scientists and communicated to Health Platforms in reports and meetings.

The anticipated insights and outcomes from the prioritised HVN Health Platforms will begin to identify nutritional approaches to health and wellness. At this point these platforms will need foods with which to test their hypotheses in laboratory and clinical trials. Objective 2: Bioactive Food Systems addresses this need by translating nutrient delivery targets into model food products, using strategic insights from Opportunity 1. This activity will leverage the Riddet Institute's world-leading capability in nutrient microencapsulation and food structure design, and will use cutting edge *in vitro* and *in vivo* digestion models to modulate nutrient and bioactive bioavailability according to the needs of Health Platforms.

SCIENCE RATIONALE

Objective 1: Food Science - Scanning the Horizon aims to keep health platforms on target by identifying emerging new avenues and new barriers to commercialisation. Sharing of breaking news on emerging food formats for conveying bioactives will provide a strong basis for crosstalk – for rich engagement between HVN and companies and across HVN platforms.

Objective 2: Bioactive Food Systems aims to develop innovative food products with proven health claims, HVN needs to address several critical challenges, including discovering the potential bioactivity of beneficial compounds, establishing optimal intake levels, and developing adequate food delivery matrix and product formulations. Bioactive food systems may take the form of foods fortified with exogenous nutrients (e.g. vitamins, minerals, phytochemicals), or of foods structured in such a way as to release endogenous nutrients in a biologically optimal way, e.g. controlled glycaemic impact or *in vivo* generation of bioactive peptides. Both approaches will be canvassed according to the needs of Health Platforms. The evolving specific needs of each Health Platform will be closely monitored and communicated by the Science of Food team member embedded in that platform, to ensure that work done by the Science of Food team is 'fit for purpose'.

RESEARCH PROGRAMME

THE RESEARCH TEAM

P.I.: Prof. Richard Archer (Institute of Food, Nutrition and Human Health, Massey University).

A.I.s: **Distinguished Prof. Harjinder Singh** (Riddet Institute, Massey University) is Co-Director of Riddet Institute (A Centre of Research Excellence); **Prof. Phil Bremer** (Food Science, University of Otago); **Prof. Charles Brennan** (Chair of Food Science and Nutrition, Lincoln University, Christchurch); **Dr Jolon Dyer** (Science Group Leader: Food and Bio-Based Products, AgResearch); **Dr Simon Loveday** (Research Officer, Riddet Institute, Massey University).

GOAL

To provide a near-continuous stream of up-to-date, tailored intelligence on international practice in development of foods for health.

RESEARCH PLAN (FROM MID-2015 TO END-2018)

We will conduct a thorough search in 2015 and set up a search and alert system for annual updates. Information will be compiled, evaluated, interpreted and reported for non-food scientists. Reports will be tailored to the various HVN health platforms. Intelligence will be trapped in reports and discussed in annual dialogues with each platform.

Objective 1: Food Science - Scanning the Horizon

- **Milestone 1:** To establish a search algorithm to glean information on wellness food systems and 'foods for health' regulations in key jurisdictions (begin middle of 2015, end by late 2016). Including;
    - To establish the suite of suitable information and search services for approvals, launches and company activity (by end of September 2015).
    - To establish a system for trading information and analysis with the HVN stakeholder network (by end of September 2015).
    - Provide an automated, highly filtered, alert system covering patents and scientific publications in the area of food and beverages with specific health benefits (by end of December 2015).
    - Develop a system for trapping changes (both upcoming and actual) to regulatory policy or process covering health claims for food materials in China (CFDA & AQSIQ), Europe (EFSA), USA (FDA) and Australia-NZ (FSANZ) (by end of December 2015).

- **Milestone 2:** Use the search algorithm to scan the past five years of approvals, launches, patents and publications. Render this information into a single report for each health platform. Including;
    - Provide a comprehensive report on the health claim regulatory system by jurisdiction.
    - Compile reports and search data for approvals and company activity covering 2010 to 2015 (by end of April 2016).
    - Evaluate data and prepare as a single report for each HVN platform identifying trends in products, technologies, regulatory approach, volume of activity and favoured matrices.

- **Milestone 3:** Update this report in 2017, 2018.

As a result of the involvement of Science of Food team members in the development of Health Platform proposals, we anticipate that health platforms will require a mixture of endogenous nutrient fortification technologies and exogenous nutrient modulation approaches. Objective 2 will start once Objective 1 is nearly complete and Health Platforms have begun to identify target nutrients for bioactive foods, which is expected to be mid-2016.

Objective 2: Bioactive Food Systems

- **Milestone 1**: To meet with each Health Platform to discuss their needs relating to food systems for laboratory and/or clinical testing.
    - Write a development brief (including costings and time frames) for producing a model bioactive food for each Opportunity (begin middle of 2016, end late-2016).

- **Milestone 2:** To Adapt or develop nutrient encapsulation approaches suitable for the fortifying foods with nutrients identified by Health Platforms.
    - As required - Measure loading capacity, encapsulation efficiency and *in vitro* bioavailability of the target nutrient (begin late 2016, end mid 2017).

- **Milestone 3:** To adapt or develop food structuring approaches suitable for modulating release of endogenous nutrients identified by Health Platforms.
    - As required - Measure kinetics of release during simulated *in vitro* digestion (begins late 2016, end mid 2017).

- **Milestone 4**: Commencement of production of model food products based, ensuring compliance with food safety standards and regulatory constraints (begin mid-2017, end mid-2018).

- **Milestone 5**: Develop consumer-ready prototype food products.
    - High sensory appeal among target market consumers (begins mid-2018, end by end of 2018).

RESEARCH METHODOLOGIES

We will seek out and use existing information already compiled by services round the world, including a focus on China, and generate a co-operative approach across multiple companies for what is essentially public domain (yet hard to discover) information. We will monitor the scientific, patent and regulatory literature, and generate a tailored monthly search system to provide alerts in the target and focus areas. We will monitor regulators' websites and use a network of close observers of regulatory activity from within and without regulatory bodies. The information "machine" will be operated to find all reports of the target and focus areas over the prior five years. The data from the various sources will be combined and common trends identified, and the outcomes will be reported to HVN health platforms and Science of Food Opportunity 2. A series of meetings will be held between the Science of Food and each of the Health platforms to both convey the information determined and to refine searches in future. Annual reporting will become more focused as the health platforms gain a greater appreciation for the types of active species involved, and the food systems best suited to conveying them.

The experience and international networks of Science of Food team members will be leveraged to maximise impact and science stretch. Bioactive delivery technologies [1, 2 3-6], plus well-characterised examples and IP-protected novel structures whose potential is unexplored are areas of high science stretch. Advanced *in vitro*[7], *in vivo*[8], *ex vivo*[9], and *in silico*[10] approaches are available for measuring the breakdown of food and delivery of nutrients during digestion will be applied. Consumer appeal will be measured using scientifically rigorous sensory testing under controlled conditions (e.g. 'temporal dominance of sensation' testing[11]) to quantify the nature and magnitude of sensory influence exerted by the bioactive loading of foods. Hedonic testing with recent Asian migrants will establish the acceptability of model bioactive-loaded foods with target consumers, and will verify that sensory properties are superlative. Food safety activities will use best practice HACCP methodologies, integrated hurdle technology approaches to process and formulation, predictive microbiology and advanced toxicology models.

RESEARCH OUTCOMES

Regular reports summarising relevant global developments and providing strategic guidance to Health Platforms and Opportunity 2. A series of meetings with Platforms and the Stakeholder Network to convey and discuss these reports.

The delivery of the science of food insights and outcomes will both guide and enable the formulation of prototype, through to consumer ready foods. The engagement is both to facilitate the research objectives of the health themes, but to also create effective industry engagement and knowledge transfer.

2019-2024 RESEARCH PLAN

Continuation of the information search and summary approach, with greater focus on the evolving needs of Health Platforms.

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3. METABOLIC HEALTH

BACKGROUND

The Asian consumer is rapidly developing myriad problems of weight gain and cardiometabolic (CM) disease so prevalent globally. Asians are at far greater risk of poor metabolic health than their Caucasian counterparts, at a younger age and lower body weight[1,2]. China is home to ⅕ of the world's population of >1.5B overweight[3], metabolic disease affects up to 60% of adults[4,5] where CM diseases are the leading cause of morbidity, having doubled in 20 yrs[1,6]. Soon >60% of the world's diabetic population will be in Asia[7], where a staggeringly high 500 million already have poor metabolic health and type 2 diabetes,[8,9] with predictions for > 0.5B by 2030[10].

Asian ethnicities are at far greater risk of adverse metabolic health than their Caucasian counterparts, developing metabolic syndrome and type 2 diabetes at a younger age and lower body weight[1]. Little resilience to Western lifestyle means even modest weight gain leads to rapid metabolic dysregulation, yet the mechanisms remain little understood. Amongst Asians impaired insulin secretion and action appear to be significant aetiological factors for diabetes, and IR is more pronounced than amongst people of other ethnicities[32]. The relationship between obesity and metabolic health, whilst causative in many individuals where excess adipose mass drives IR, is complex. Intriguingly, not all overweight have impaired glucose tolerance (IGT) or diabetes, and not all individuals with type 2 diabetes are obese. Recent data confirmed that in Chinese Asians metabolic biomarkers are better predictors than body weight/adiposity alone[33], and hence key to target with food solutions; highlighting the importance of (i) understanding the mechanism underpinning these metabolic risk factors, (ii) predicting which individuals are at increased risk, and why; and (ii) targeting these biomarkers using nutrients, foods and food products to ameliorate these adverse effects.

The global diabetes market is predicted to be worth $45B by 2020,[11] with China alone 3rd largest globally and growing to $3.5B[12] in 2017, and clear opportunity for the F&B sector with annual health costs of $365B but only $235M as yet spent on functional foods. Diabetes reached MegaMarket status in 2006 and is among the fastest growing opportunities.[13] In Asia traditional teas top the ratings within the sector for metabolic health, where Asian consumers are looking for better food solutions. Messages such as '*foods for blood sugar control'* resonate[14] both for themselves and for their burgeoning children and adolescents who are developing metabolic health problems in unprecedented numbers.[8]

The Opportunity in metabolic health is "Peak Nutrition for Metabolic Health" which will deliver F&B insights and solutions to meet the needs of consumers seeking to maintain good metabolic health throughout their life span, through validated functional foods that:

- regulate insulin, glucose and associated metabolic health – for *better glycaemic control;* and
- regulate body weight and composition – to *decrease central adiposity and enhance lean mass*

Examples of Consumer needs and benefits are new foods that will help individuals:

- maintain a healthy blood glucose, insulin, lipid profile; maintain healthy blood pressure

SCIENCE RATIONALE

The physiological goals for optimal metabolic health are to maintain normal blood glucose, lipids, and blood pressure within a healthy range[34]. Core components of advice for prediabetes are prevention of weight gain or weight loss, consuming less refined carbohydrate/high GI foods/saturated fat, and more dietary fibre[28]. There is a large literature of food-interactions with modifiable metabolic health markers,[35-40] including those of relevance to a range of NZ industries, for example higher protein foods for improved body composition, Hb_{A1c}, fasting/postprandial glucose, insulin, lipids, blood pressure[31,41], as well as novel biomarkers of risk e.g. peptides, 2-aminoadipic acid, islet amyloid.[42-44] Fibre-rich products facilitate weight and glycaemic control[35,36,45] where modification of physical structure alters glycaemic response[35,36]; horticultural crops (e.g. berryfruits, kiwifruit) rich in polyphenols may exhibit beneficial metabolic health and anti-inflammatory activity, and have been hypothesised to target underlying pathology of the pancreatic β-cell, with evidence from animal models[46].

However there are significant knowledge gaps. This includes the identification of those who are most at risk of adverse metabolic health; what is the risk phenotype, are there early risk biomarkers; why are some obese individuals protected (resilient profile) and others at increased risk (non-resilient profile, e.g. Asian ethnicity);

how does adipose tissue 'communicate' with key sites of metabolic regulation; is the region of adipose deposition a 1ry regulator of metabolic health; what are the key molecular mechanisms that underpin pancreatic dysfunction, regulate response to nutrient intake, and how can they be targeted by foods.

The aims of the Peak Nutrition for Metabolic Health is to develop F&B opportunities achieved through an interdisciplinary programme focused on delivering: (i) identification of mechanisms which underpin regulation of glucose, insulin and metabolic health markers; fat deposition & lipid overspill; enhanced lean mass; (ii) prediction of early risk biomarkers, using advanced 'omics platforms, and development of food strategies to target both established and novel early risk biomarkers; (iii) development of consumer activation tools to increase Asian consumer awareness of metabolic health, food solutions and promote product uptake; (v) the validation of new food solutions for the Asian marketplace from high quality NZ-origin products with enhanced structure, composition, delivery and efficacy.

This will be achieved with the Establishment of a NZ-wide Metabolic Interdisciplinary Multi-user Platform - $Metabolic_{IMP}$ to enable quicker, more cost effective, clinical validation of foods to deliver mandated high quality clinical data to regulators. Comprising *in silico* pathway analysis, molecular proteomic, metabolomics, epigenetic profiling, cell based nutrient screening assays and clinical studies, $Metabolic_{IMP}$ will drive a balanced mission-led programme of biomarker investigation and clinical evaluation, generating unique insight into early predictors of the loss of metabolic health and targeted biomarkers response to foods that are associated with improvements in metabolic health.

RESEARCH PROGRAMME

THE RESEARCH TEAM

P.I.: Prof. Sally Poppitt (Fonterra Chair in Human Nutrition and Director, Human Nutrition Unit, UoA)

A.I.: Dr Lisa Te Morenga (Ngāti Whātua, Te Rarawa, Senior Research Fellow, University of Otago); **Dr Jan Huege** (Senior Research Scientist, AgResearch, Palmerston North); **Justin O'Sullivan** (Senior Research Fellow, University of Auckland); **John Ingram** (Senior Scientist, P&FR, Auckland); **Prof. Paul Moughan** (Co-Director, Riddet Institute) .

Other researchers aligned with Metabolic Health: include Dr Rinki Murphy (DeptMedicine, Consultant Diabetologist, UoA, Maurice Wilkins CoRE), Prof. Garth Cooper (UoA, Diabetologist; Director, Centre of Advanced Discovery & Experimental Therapeutics, (CADET), UK and visiting Professor, Hong Kong & Guanzou, China), Dr Jack Flannagan (FMHS, MW CoRE, UoA).

International alignments A* Singapore (BAC cohort); FP7 EU PREVIEW[15].

GOAL

To create new opportunities for NZ F&B industry and deliver validated claims for better metabolic health, achieved through research outcomes from key interdisciplinary expertise within NZ and Internationally

RESEARCH PLAN AND METHODOLOGIES

A sequence of objectives have been established, based on the overarching hypothesis that lipid 'overspill' from adipose into metabolically active organs including, muscle, liver and pancreas results in compromised metabolic health. Central to this is pancreatic β-cell dysfunction causing impaired blood glucose regulation (hyperglycaemia) and increased metabolic health risk. Further, that Asian ethnicities are non-resilient to these events and that predictive biomarkers can be identified[56]; and used to target food solutions.

OBJECTIVE 1: Characterising the prediabetes phenotype.

The prediabetic Asian phenotype will be identified using a targeted systems approach: Asian populations are at increased metabolic health risk, developing diabetes at a younger age and lower BMI^2 than Caucasian counterparts. However, the relationship between obesity and metabolic health is complex, and not always causative, with evidence in Asians that established risk markers may better predict development of diabetes than body fat alone[33], yet predictors remain poor.

- **Milestone 1**: Establishment of clinical trial platform to enable internationally validated gold standard, interventions to generate high level of scientific evidence mandated by regulatory bodies[52] (Yr 1).

- **Milestone 2:** Recruit overweight, prediabetic and healthy, male and female adults, Asian and Caucasian, for cross-sectional metabolic risk profiling using Metabolic$_{IMP}$ (Yrs 1-2); *building* on current BAC cohort of 50 lean, 50 overweight Asian women in Singapore; also significant additionality for NZ achieved by mapping clinical samples from other National Cohorts of prediabetics PREVIEW:NZ and NSC Healthier Lives into this programme of biomarker profiling.

- **Milestone 3:** Identify candidate biomarkers of prediabetes using Metabolic$_{IMP}$ 'omics capability (Yrs 1-3): In Silico Modelling & KEGG pathway analysis in foods & metabolised products; build metabolite-protein networks for pathways targeted by foods; utilising proteomics - high throughput protein analysis, quantification using MS; metabolomics - broad spectrum metabolite analyses, utilising GC-MS and LC-HR MS; (epi)genomics- novel ChIP-seq for DNA histone/methylation modifications. Transcriptomics - gene expression response to foods.

- **Milestone 4:** Identify key food targets using Metabolic$_{IMP}$ (Yr 3).

OBJECTIVE 2: Characterising metabolic health and diabetes risk
Whilst causation of diabetes remains under debate, significant evidence supports abdominal fat and lipid overspill as critical risk factors for diabetes[57], with Asian ethnicity least resilient to metabolic sequelae. How adipose depots differentially alter metabolic health risk is not known. Further the transition from a pre-diabetic state towards diabetes is not known. Progress is hampered by little insight into mechanisms that result in the loss of pancreatic β-cell function. Insoluble deposits of human amylin (hA) fibrils are cytotoxic to pancreatic β-cells, triggering IR and hyperglycaemia[58], with evidence that they are amenable to food solutions[46].

- **Milestone 1**: Identify risk biomarkers in 25 obese women from the *Auckland Hormones & Obesity Surgery* cohort and Metabolic$_{IMP}$ (from Obj 1); profile blood and adipose tissue at 3 regional sites: peripheral, subcutaneous abdominal, visceral abdominal (Yrs 1-2).

- **Milestone 2**: Identify predictive biomarkers of hA fibrils in a prediabetic and diabetic cohort using Metabolic$_{IMP}$ (from Obj 1) (Yrs 1-2).

- **Milestone 3**: Identify key food targets using Metabolic$_{IMP}$ (from Obj 1) (Yrs 2-3).

RESEARCH OUTCOMES

New capability including pan-NZ interdisciplinary network and , development of a sophisticated and cost effective tool (Metabolic Interdisciplinary Multi-user Platform; Metabolic$_{IMP}$) to enable quicker, targeted, clinical validation of food products to deliver clinical data as mandated by regulators.

Significant additionality to the current NZ research landscape including direct alignment with 10 year MBIE project *Suppressing Diabetes,* and MBIE's *Biomarker Development in Asian Populations*; also PREVIEW:NZ, and the proposed pan-NZ cohorts under development within NSC Healthier Lives.

2019-2024 RESEARCH PLAN

From 2019, the Aim is to establish a TRANSLATIONAL NZ INC. CAPABILITY to enable the rapid delivery of proof of principle clinical data through to market-ready prototype foods. The ongoing programme of discovery and validation using the targeted systems approach, Metabolic$_{IMP,}$ will continue. In addition there will be greater consumer engagement, leading to a further Objective 4.

OBJECTIVE 3: Consumer awareness/activation - toolbox development
e-technology has revolutionised consumer awareness programmes, e.g. smart phone apps, and is of particular relevance in Asia where market penetration by mobile devices in urban areas is >90%[59]. There is significant evidence of success of these methods in consumer-oriented eHealth settings[60]

- **Milestone 1**: To establish eHealth platform for Asians consumers (Yrs 2-3).

- **Milestone 2**: To evaluate e-delivery of diabetes risk info and food solutions for prevention on consumer knowledge, activation, purchasing in prediabetic Asian cohort (Yr 3).

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4. GUT & IMMUNE HEALTH

BACKGROUND

The GUT and IMMUNE HEALTH investment priority will focus on the aspirational Elite GUT and IMMUNITY of the motivated 'Worried Well' Asian consumers. Gut health and immunity are central to wellbeing and variation from the physiological norm increasingly occurs in these consumers. Indeed, both stress and ageing are known to decrease integrity and function of the gastrointestinal tract (GIT) and immune system[1-6], and GIT and immune dysfunction effects physical and mental wellness resulting in diminished productivity[7,8]. Ageing consumers are also increasingly susceptible to poor respiratory health[9], and air pollution has become the fourth biggest health threat to Chinese people[10] as densely populated areas in China are considered 'barely suitable' for living[11]. Taken together, these health needs result in a substantial target market in Asia for F&B products that improve GUT & IMMUNE HEALTH.

GIT and immune health in Asia are among the leading health positions for market share and fastest growth worldwide, with over 60% of functional food products directed at these health targets. The emerging Chinese market (particularly for the 'Worried Well') is amongst the fastest growing in this functional food market[12]. The GIT remedies category has been reported to expect a constant CAGR value of 5% from 2013 to 2018[13]; and analysis shows that 77% of Chinese consumers rank 'immune enhancement' as important[14]. The outbreak of severe acute respiratory syndrome (SARS), bird and swine flu coupled with Asia's ageing population (having lower immunity) is driving the growth of immune health ingredients[15]. To meet consumer demand the lucrative probiotics market is growing rapidly. In the Asia-Pacific market, probiotic based F&B companies earned revenues are estimated to reach US$523m by 2018, and the key target markets are China and Japan[16]. The highest impact market driver boosting sales of probiotics has been increased scientific and clinical trials to validate improved digestive health and enhance immune function[17]. Yet, the GIT and immune segments of functional foods are underexploited worldwide with potential for strong growth in new product development with validated health claims.

There are 2 prioritised opportunities in Gut & Immune Health; **Opportunity 1: Improving GIT function and comfort** and Opportunity 2: Building Immune Defences. These will generate unique opportunities for the NZ F&B industry to market new, high value F&B products with validated scientific claims. These products will profoundly influence consumers' sense of physical and mental wellness and increase their peak performance throughout the day.

SCIENCE RATIONALE

OPPORTUNITY 1: Improving GIT Function and Comfort

GIT dysfunction, stress and ageing result in reduced digestion and absorption in the small intestine[31,32], altered barrier function (central to GIT resilience) [18,19], increased discomfort[20,21], altered motility, increased local and systemic inflammation[18], and altered metabolite production by the resident microbiota, which impacts epithelial, immune and neuromuscular function of the GIT[22]. Insufficient knowledge for food-health claims means that beyond self-substantiation, critical mechanistic knowledge underlying GIT function and comfort is needed to prove dietary cause and effect relationships in target export markets. These mechanisms of action remain poorly defined.

To determine these mechanisms of action, flexibility (homeostasis) of the GIT must be challenged. IBS patients are considered the appropriate study group to support claims on improved GIT function and comfort intended for the general population, as IBS is recognised as a variation to the physiological norm[23]. IBS is a functional GIT disorder characterised by chronic or recurrent abdominal discomfort mostly associated with changes in defecation or GIT habit in the absence of a detectable organic cause[23]. The aetiology and pathogenesis of IBS is poorly understood and a number of major overlapping theories of pathogenesis exist, including alterations in GIT transit[24,25] and visceral afferent hypersensitivity[26]. Dysfunction of the bidirectional communication system between the brain and the GIT (gut-brain axis, GBA) contributes to symptomology[27]. Together with the importance of inflammation in the development of IBS, this suggests that there is crosstalk between stress factors, immune responses and the microbiota, which may worsen symptomology[4,28,29].

Thus a pivotal weakness of the current research is the relative lack of understanding of the IBS phenotype. This weakness is a risk for NZ companies aiming to make a valid food-health claim for GIT function and comfort. IBS patients are accepted by regulators as the group in whom interventions should be trialled and differences

measured using validated patient questionnaires. Equally important in making a health claim is demonstration of the mechanism of action of specific foods in such patients. In order to provide mechanistic data (using a systems approach) to support health claims for GIT function and comfort, a precisely phenotyped IBS patient cohort must be recruited. The Elite GUT research programme will have access to a large cohort of IBS patients recruited into the Christchurch IBS cOhort to investigate Mechanisms FOr gut Relief and improved Transit (COMFORT). There are no known regulatory hurdles that will reduce the likelihood of conversion of the research outcomes into valid food-health claims. Physiological GIT function (colonic transit time, stool frequency, consistency, form using Bristol Scale and increased bulk) and comfort (bloating, cramps, straining, "rumbling" and sensation of incomplete evacuation or urgency) biomarkers are accepted by regulatory bodies[23]. Clinical evidence shows a food-health relationship for GIT function and comfort using these accepted biomarkers[30-32]. ***Recognition of the COMFORT cohort as a central element of a food-health claim for Elite GUT is a unique competitive advantage for NZ to build on existing capability in food-GIT health research to deliver the outcomes to the HVN Challenge and the NZ F&B industry.***

OPPORTUNITY 2: Building Immune Defences
Frequent colds/flu are one of the top health issues for Asian consumers, with influenza epidemics occurring virtually every year[33]. The link between reduced overall productivity and cognitive impairment during respiratory tract infections is well recognised in the Asian market, and these motivated consumers demand solutions. As a consequence, the majority of Chinese patients with seasonal influenza are prescribed antibiotics despite no efficacy[34]. In addition, 75% of Chinese workers consider their stress levels have risen in the past year[35], and stress is known to impact GIT defences[36-39], alter immunity[6] and result in diminished performance and productivity[40,41]. Accumulating evidence indicates that antibiotic use and stress perturb immune defences against influenza[42-44]. In addition, the significant rise in the ageing population that is susceptible to poor respiratory health is of major concern[45], and, air pollution has become the fourth biggest threat to the health of Chinese people[10]. This rapidly increasing air pollution in China's major cities means these densely populated areas are considered 'barely suitable' for living[46].

Mucosal immunity is maintained by the dynamic crosstalk between epithelial cells, the microbiota and immune responses, all fundamental features of immune homeostasis[47]. It is well known that the GIT and respiratory systems are mucosal tissues, and it has been speculated that the mucosal immune system is itself an "organ" in which the mucosal immune cells distributed throughout the body interplay between or among different mucosal tissues[48,49]. Beyond this connection, the GIT is the most powerful immunological organ[50], making it an ideal target for food to beneficially modulate immune function.

To demonstrate immune modulation by nutrition in the general population, accepted biomarkers that both credibly demonstrate clinical relevance and beneficial modulation of immune function need to be used[51]. The major impediment of the current research is the paucity of knowledge of the causal relationship for F&B products to build immune defences. This weakness is a critical risk to NZ F&B companies aiming to make a valid food-health claim. In order to de-risk this opportunity for these companies, key knowledge that provides mechanisms of action for F&B products to build immune defences need to be determined.

RESEARCH PROGRAMME

THE RESEARCH TEAM

P.I. (OPPORTUNITY 1: Improving GIT function and Comfort): Assoc Prof Nicole Roy (Principal Scientist and Team Leader, Food Nutrition & Health AgR), is the Science Leader and Chair of the Gut and Immune Health Theme. Her experience/expertise through managing large NZ research collaborations (MBIE and CoREs) generating pre-clinical tools/models/knowledge of GIT function and comfort.
P.I. (OPPORTUNITY 2: Building Immune Defences): Dr Elizabeth Forbes-Blom (Senior Research Fellow and Team leader at MIMR) will utilise her expertise in diet, host-microbiota interactions and immune function (pre-clinical models).

A.I.: Assoc Prof Richard Gearry (Department of Medicine at the University of Otago and Consultant Gastroenterologist at Christchurch Hospital);**Dr Janine Cooney** (Team Leader for Physiological Chemistry, PFR);**Dr Karl Fraser** (Senior Research Scientist, AgR); **Assoc Prof Shane Rutherfurd** (Riddet Institute, Massey University); **Prof Roger Hurst** (Principal scientist and Science Group Leader, Food & Wellness Group, PFR); **Dr Jacquie Harper** (Senior Scientist and Group Leader, Arthritis and Inflammation at MIMR) will provide expertise in cell and molecular biology and respiratory inflammation.

***Other considerations* (OPPORTUNITY 1: Improving GIT function and Comfort)**. The team proposes to engage with NZ researchers: Prof Roger Mulder (Canterbury), psychological assessment; Dr Paula Skidmore (Otago), nutritional evaluation; Dr Julie Dalziel (AgR) and Prof Roger Lentle (Massey), pre-clinical models of

motility; Drs Wayne Young and Rachel Anderson (AgR), host-microbe physiology; Prof Grant Butt and Michael Schultz (Otago), organoid/enteroid models; Dr Doug Rosendale (PFR), microbial fermentation; Dr Tim Angeli (Auckland), mathematical GIT modelling; Dr Stefan Clerens (AgR), proteomics; and Dr Arjan Scheepens (PFR), neuroscience. Internationally, the team proposes to engage with Prof Nick Talley, Pro-Vice Chancellor, Health and Medicine at the University of Newcastle in Australia, who is a world leader in functional GIT disorders (>1000s publications). A recent publication from his group reports that a combination of gene expression and serological markers in combination with psychological measures differentiates IBS from healthy patients[52]. The team will also establish collaboration with Atlantia Food Clinical Trials (Ireland)[53], which has a core competency in EFSA-based health claim validations. The team will also collaborate with Profs Jerry Wells (Wageningen University, host-microbe interactions), Paul O'Toole (APC, microbial genomics), John Cryan (APC, neuroscience) and Nick Spencer (Flinders, neurophysiology) to support the mechanistic research.

Other considerations **(OPPORTUNITY 2: Building Immune Defences).** The team proposes to engage with NZ researchers: Drs Tao Zheng and Axel Heiser (AgR), respiratory tract infection; Dr Wayne Young (AgR), models of microbe and host interactions; Drs Hazel Poyntz and Lieke van den Elsen (MIMR), host-microbiota regulation of protective immunity; Dr Odette Shaw (PFR), models of respiratory inflammation; the ESR-led SHIVERS (Southern Hemisphere Influenza and Vaccine Effectiveness, Research and Surveillance) project; Dr Nikki Turner (ESR), vaccination RCTs; and Dr Richard Beasley (MRINZ), food intervention for immune responses. **Internationally**, the team proposes to collaborate with Prof Kathy McCoy and Dr Markus Geuking (University of Bern and University Hospital Bern), host-microbiota interactions impacting immunity; Prof Charles Mackay (Charles Perkins Centre and Monash University), diet and GIT microbiota to reduce inflammation; and Prof Johan Garssen and Assoc Prof Leon Knippels (Utrecht University and Nutricia Research), human food intervention studies to modulate immune function.

The team's collective RS&T track record provides critical knowledge and cutting edge expertise relevant to immune defences with a proven track record of research delivery for MBIE, HRC, Marsden and NZ and international F&B industries. The team have access to extensive research infrastructures including clinical facilities (Otago), animal facilities (AgR, Massey, MIMR, PFR), immunology platform (MIMR), microbiota platform (AgR, Otago), transcriptomics, proteomics, metabolomics and bioinformatics platform (AgR, PFR, Otago).

GOAL

To create new opportunities for the NZ F&B industry and deliver validated health claims for GUT & IMMUNE HEALTH through research outcomes from the key interdisciplinary expertise engaged in this programme.

RESEARCH PLAN AND METHODOLOGIES

OPPORTUNITY 1: Improving GIT function and Comfort
The key hypothesis is that the GIT is a critical component of the GBA, and GBA signalling underpins the beneficial effects of foods on GIT function and comfort with flow on effects to the brain.

OBJECTIVE 1: Advance the diagnostic predictability of IBS phenotypes
The definition and diagnosis of IBS is challenging[54]. Diagnosis is made using clinical criteria (Rome III) that allows classification of patients into diarrhoea, constipation or pain predominant phenotypes. The underlying pathophysiology of all Rome III defined IBS phenotypes are poorly understood, leading to a number of key challenges. There are no robust laboratory biomarkers, therefore, clinical studies need to use subjective patient reported measures to determine efficacy; given placebo response rates can be as high as 40%. Animal models of IBS poorly reflect the human condition and positive results in animal studies have often not translated to successful clinical outcomes in human subjects.

- **Milestone 1:** Determine cohort stratification of 300 IBS and healthy subjects against the major phenotypes based on existing biomarkers of GIT function and comfort (Yrs 1-2). Patients presenting to gastroenterologists with functional symptoms requiring colonoscopy will be part of the study. Age and sex matched individuals undergoing colonoscopy for screening/surveillance without functional GIT symptoms will be recruited as controls. Demographic data will be recorded and dietary assessment will be conducted in collaboration with a nutritional epidemiologist. GIT assessment, quality of life, and psychological assessments will be done using validated questionnaires. Existing biomarkers/metabolic pathways will be assessed in body samples in Milestone 2.
- **Milestone 2:** Utilise a systems approach on tissue/fluid samples from a subset of the COMFORT cohort to establish mechanistic insights into at least one IBS phenotype (Yrs 2-3). The systems analyses will complement the phenotypic data of the COMFORT cohort.

OBJECTIVE 2: Verify the causative effects of microbiota on GIT function and comfort.
While altered GIT motility, sensation and hypersensitivity are thought to be critically important in IBS development, the GIT microbiota has been recently proposed as a causative factor. Evidence suggests activation or up-regulation of factors involved in microbial-host interactions and host defence mechanisms against the microbiota are important for improving GIT function and comfort[55].

- **Milestone 1:** Determine the microbiota signature and the metabolites they produce in faeces of IBS and healthy subjects identified from a subset of the COMFORT cohort from Objective 1 (Yrs 1-2).
- **Milestone 2:** Identify the causal relationship between microbiota and existing biomarkers of GIT function and comfort using experimental models (Yrs 2-3). Germ-free and conventional rodents will be used to determine how the microbiota affects GIT function and comfort. Where appropriate, an isolated whole large intestine from the rat and animal models of GIT transit[56] will be used to evaluate their effects on motility. Similarly, a unique cell-based model that combines dual-environment co-culturing of obligate anaerobes (from Milestone 1) and intestinal cells to understand their mode(s) of action[57]. Understanding the role of substrate utilisation and metabolite production by the GIT microbiota will be done using PFR's 3-stage pH controlled, continuous stirred fermenter which mimics the environment of the large intestine[58]. Together these analyses will provide data that will increase the predictive validity of existing biomarkers in clinical studies.

OPPORTUNITY 2: Building Immune Defences
The knowledge gaps in our understanding of the mechanisms of action that build immune defences will be addressed to provide (i) a causal relationship for the beneficial modulation of immune defences, (ii) clinically relevant biomarkers (established and new) of the immunological processes, and (iii) clinical efficacy of these biomarkers.

Objective 1: Host-microbiota targets to build immune defences

Antibiotic use and stress alter GIT microbiota composition (dysbiosis) and host-microbiota interactions, leading to reduced immune defences. The key hypothesis is that restoration of appropriate host-microbiota interactions underpins the beneficial effects for food to build immune defences.

- **Milestone 1**: Demonstrate the negative impact of altered host-microbiota interactions on immune defences to influenza (Yr 1). The team will establish three robust pre-clinical models of dysbiosis (naturally divergent, antibiotic treated or stress-induced) to examine the impact on immune defences against influenza. TIV vaccination will be employed, and the generation of TIV-specific IgG in the serum will be examined kinetically over an 84 day period, as well as associated T and B cell responses[43]. Evidence that host-microbiota interactions can be modulated by food and impact immune defences against respiratory tract infections will be assessed (go/no-go step at Yr 1).
- **Milestone 2:** Establish an appropriate human cohort to examine the impact of host-microbiota interactions on immune defences (Yrs 1-3). The team needs to determine the best approach to generate a clinical cohort to examine the impact of host-microbiota interactions for respiratory immune defence (go/no-go step at Yr 1). This will include discussion with the leaders of the SHIVERS cohort (including potential utilisation of this existing cohort) as well as MRINZ and P_3 Research for cohort design. This will provide access for the Elite IMMUNITY programme to a clinical cohort to determine seroconversion and seroprotection following vaccination. Host-microbiota interactions will be examined including intestinal barrier function, secretory IgA production and GIT microbiota composition and metabolic pathways (as described in Opportunity 1 Objective 1 Milestone 2) in association with immune defence outcomes. In addition, pathogen-specific T and B cell responses will be examined in peripheral blood.
- **Milestone 3**: Identify pre-clinical and clinical host-microbiota targets that regulate immune defences (Yrs 1-3). The team will determine how dysbiosis results in defective host-microbiota interactions, including intestinal barrier function, the generation of antimicrobial peptides, mucous production and secretory IgA translocation. Mechanisms of action that result in intestinal immune injury that are likely to impact respiratory immune defence will also be investigated[59]. Challenge to immune defences in vaccinated animals will also be employed to evaluate GIT defence and immune protection biomarkers. Finally, GIT microbiota composition and metabolic pathways (overlap with Opportunity 1) will be examined in association with immune defence outcomes.

Objective 2: Mechanisms of pollution exacerbated respiratory inflammation

The key hypothesis for objective 2 is that the management of inappropriate inflammation underpins the

beneficial effects of foods to build immune defences to improve respiratory function in poor air quality environments.

- **Milestone 1:** Develop two robust animal models of pollution-mediated respiratory inflammation that demonstrate the negative impact on respiratory immunity. The team will establish pre-clinical models of respiratory inflammation to examine the impact of pollution on immune defences in the lung alone (model one) and in combination with allergic airways inflammation (model two). Evidence will be gathered to illustrate that pollution-mediated respiratory inflammation can be modulated by food (go/no-go step at Yr 1).
- **Milestone 2:** Completion of analyses from Milestone 1 will include identification and validation of accepted and new blood biomarker panels (using Objective 1 systems approach) and functional measures (e.g. airway resistance) that enable translation into measurable and clinically relevant outcomes. The role of dysbiosis on pollution-mediated respiratory inflammation will be assessed using the methodologies optimised in Objectives 1 and 2 (Milestone 1) (Yr 2).
- **Milestone 3:** Evaluation of the efficacy of lead food candidates in animal models. Functional and biomarker outcomes (validated in animal experiments) will be used to define mechanistic relationships to efficacy and inform choice of food candidates for clinical evaluation (Yrs 2-3).

RESEARCH OUTCOMES

Understanding the mechanisms underlying GIT function and immunity that are critically needed to assess food-health claims requires the proposed multidisciplinary approach including nutrition, food, (bio)chemistry, physiology, immunology, microbiology, pre-clinical and clinical expertise and application of platform "omics" capabilities. This will be achieved using an integrated approach that is beyond the capabilities of the individual teams involved in this collaboration. This consolidation of expertise and cutting edge technology will result in critical mass, human capability development, new models, tools and high impact publications that are necessary to deliver the aspirational vision of Elite GUT and IMMUNITY.

2019-2024 RESEARCH PLAN

The goal beyond 2019 is to establish by 2024 a translational NZinc capability for nutritional improvement of **Elite GUT and IMMUNITY** as a consequence of a significant depth of understanding of the mechanisms and pre-clinical experimental data. The transition into clinical validation is an exciting yet challenging research advance that has the potential to generate F&B opportunities for the mitigation of stress responses and to support gut and immune health by 2024.

Objective 3: Pilot studies.

- The establishment of pilot clinical studies of beneficial food candidates. Biomarker and functional readouts will be evaluated in cohorts with defined poor GIT and immune health.

Objective 4: Application of platform capabilities for new mechanisms of GIT and immune health.

- Utilising previously identified lead food candidates. The optimisation of a comprehensive suite of technologies including next-generation sequencing, targeted differential proteomics, metabolomics-based analysis and assessment of the microbiota function, which is crucial to understand the causative mechanisms of GIT functional regulation, host-microbiota interactions and effects beyond the GIT (e.g. brain via GBA; lung). Additionally, immunophenotyping and inflammation capabilities will enable insights into beneficial modulation of immune function, and will define the causal relationship for immune outcomes and analysis of benefit in clinical studies.

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5. WEANING FOOD FOR HEALTH

BACKGROUND AND SUMMARY

Allergic diseases are increasing unabated throughout the world. Nearly 40 million Japanese suffer from allergies, almost one in three people. In China, allergic disease is now recognized as a major problem [1-3]. With the projected growth of the Chinese population over the next decade, the burden of allergic diseases is expected to increase considerably. It will face similar problems as evident in Westernised countries now, markedly increasing prevalence of allergy, including asthma, atopic dermatitis, hay fever, and allergic sensitisation to food antigens.

Weaning is a period of marked physiological change. The introduction of solid foods and the changes in nutritive milk is accompanied by significant GIT, immune and developmental adaptation. It is in this period of weaning that there are new opportunities for the development of foods and beverages that aid in the maintenance of optimal health, but can impact significantly on the risk of early life wellbeing. One key area is the development of the immune system and the risk of allergic disease. Recent attention is focused on the GIT microbiota.

Baby food products are the fastest growing product category in China's supermarket retail sector and characterised by its strongly science-driven innovations. Much of the growth in the baby food category came from the sales of baby cereals (US$2.3b sales). Fortified/functional yogurt recorded the fastest value growth with increasing number of yogurt products aimed at children with fortified/functional biscuits recording the second-highest retail value growth. The predicted baby boom in China (since more 80ers - Chinese born between 1980 and 1989 have married) will support strong volume growth. In addition, quality will continue to be consumers' main focus in baby food, reflected by the growing popularity of premium brands with higher unit prices. Dried and prepared baby foods are forecasted to substantially grow, offering many opportunities for companies wishing to enter this market.

Since the introduction of the concept of functional foods in Japan in the 1980s, there has been continual growth in the market for prebiotics, probiotics and synbiotics, which can improve human health and it is now the second largest category in NZ natural ingredients market, second only to marine oils. Crucially, pre- and probiotics are now known to elicit their health benefits through modulation of the GIT microbiota[4,5], and recent studies now implicate that the establishment of the pioneer GIT microbiota in early life has major lifelong consequences for the function of the host's immune system.

SCIENCE RATIONAL FOODS FOR HEALTH

A child that avoids the adverse effects of allergy in the first 12 months of life has a reduced risk of developing allergic disease in later life, will provide consumer pull from parents. Observational human studies have shown an association between microbiota composition and allergic disease[6-8]. Additonally, animal studies have shown that mice prone to food allergy have a signature microbiota that can transmit allergic disease susceptibility to another animal[9]. These data illustrate that the microbiota play a key role in allergic disease processes, with specific bacteria now being identified. Therefore, there are opportunities to develop foods and beverages that provide both taste and convenience with functional potential to support immune development and reduce development of allergy in early life. Thus, the identification of F&B solutions that augment the functional capacity of the GIT microbiota in early life and support optimal immune development in adulthood is a high priority.

Recent discoveries have highlighted how the infants immune system co-evolves with the GIT microbiota in a mutualistic relationship, a crucial event that impacts on the function of the host's immune system throughout life [10-12]. Indeed, the absence of GIT microbial colonisation results in a poorly developed immune system and high susceptibility allergic disease [13-15]. A major impediment to improving the outcomes for allergy sufferers is the lack of detailed knowledge of how the GIT microbiota-immune interactions in early life can regulate immune homeostasis and prevents the development of allergic responses.

GIT microbial growth is tightly linked to nutrition. Comparative metagenomics studies have underscored the dominant role played by diet in shaping the configuration and function of the GIT microbiota[16,17]. GIT

microbiota also mediate the extraction, synthesis and absorption of many key nutrients and metabolites[18]. Thus, the response to diet and dietary components can lead to significant changes in GIT microbiota composition and function. Microbial fermentation products such as short chain fatty acids provide one of the clearest examples of how nutrient processing by the microbiota and host diet combine to shape immune responses, attenuating inflammation and promoting healthy immune responses[19-21].

Therefore there is a unique opportunity in the Asian market for F&B products designed to mitigate allergic responses, through beneficial modulation of GIT microbiota-immune interactions. This research will generate key knowledge that is necessary to underpin the development of food-health claims for supporting infant immune development and prevent the development of allergic disease.

RESEARCH PROGRAMME FOODS FOR HEALTH

Clear epidemiological evidence suggests a critical period in early life where environmental cues result in life trajectory towards health, or increased susceptibility to allergy[22-25]. The neonatal immune system matures during this period[26], yet the signals that lead to its appropriate maturation and the avoidance of allergic disease development remain unclear. Recent cutting edge data now indicates GIT microbiota colonisation in early life is a key environmental cue that may regulate allergic disease susceptibility[13,27].

Objective 1: Immune maturation

The key hypothesis is that the GIT microbiota are critical in immune maturation and that impaired colonisation results in dyregulated immune responses that lead to an increased risk for allergy.

- **Milestone 1:** Determine the immune maturation consequences that result from altered choreography of the acquistion and composition of the GIT microbiota (2016-2017).
    - Pre-clinical models of disrupted gut microbial assembly in early life (caesarean section and perinatal antibiotic exposure) will be utilised to replicate the unintended consequences of these interventions using mice reared under highly controlled environmental conditions. Quantitative immunophenotyping of the immune responses in the GIT as well as systemic immune responses will be performed to determine the vulnerable immune maturation checkpoints that are regulated by GIT microbiota colonisation in early life. GIT microbiota composition and metabolic pathways will also be assessed.
- **Milestone 2:** Demonstrate the negative impact of altered acquisition and composition of the GIT microbiota on the development of allergic disease (2018-2019).
    - The models developed in milestone 1 will be employed to elucidate the impact of altered GIT microbiota colonisation on the susceptibility to allergic disease, through the food-induced allergic diarrhoea model [28]. Mice will be sensitised to the chicken egg allergen ovalbumin (OVA), and subsequently challenged via oral administration of OVA, resulting in the development of allergic diarrhoea. Immune biomarkers of allergic responses such as OVA-specific IgE, mast cell activation and number and the immune cell populations in the small intestine will be assessed.

Objective 2: Microbiota for allergy management

The key hypothesis for objective 2 is that nutritional restoration of desirable microbiota composition and metabolite production during the weaning period will mitigate allergic disease.

- **Milestone 1:** Establish the efficacy of nutritional targeting of the microbiota-immune axis for allergy management in the pre-clinical setting (2019-2020).
    - The models used in objective 1 will be employed to determine the ability of food candidates to modulate immune function during the weaning period and reduce food-induced allergic responses. Changes to GIT microbiota composition and metabolic pathways will be determined in association with allergy management outcomes.
- **Milestone 2:** Establish the efficacy of nutritional targeting of the microbiota-immune axis for allergy management in infants with altered GIT microbiota (2020-2022).
    - Infants of weaning age who consume amino acid based formulae for the dietary management of diagnosed cow's milk allergy will be recruited through allergy specialists in the Auckland region. Immune parameters in peripheral blood samples, skin prick testing and GIT microbiota composition and metabolic pathways will be examined. The exemplar food candidate for allergy management as identified in objective 2 milestone 1 will be utlised to determine clinical efficacy, and immune parameters in peripheral blood samples, skin prick testing and GIT microbiota composition and metabolic pathways will be studied as compared to control cow's milk allergic infants.

Understanding how diet and nutritional status influence the composition and dynamic operations of the GIT microbiota and immune system in early life represents an area of scientific need, opportunity and challenge.

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VALIDATING AND REFINING THE PRIORITISED RESEARCH PROGRAMMES

The five identified prioritised research programmes at the present time are not yet contract ready. Ongoing consideration, validation and refining is required to both inform and validate the investment.

TIMING, SEQUENCING AND PERFORMANCE HURDLES

The identified prioritised research has established milestones in addition to STOP/GO considerations. The prioritised research for **Consumer Insight** and **The Science of Food** commences with an initial investment in generating necessary data to aid in the refinement of the research activities within the health programmes. In a timed sequence and aligned with the health areas, further investment in these 'enabling' programmes will be made to align and refine the research activities.

Metabolic Health and **Gut and Immune Health** have proposed research primarily targeting mechanisms of action and either pre-clinical validation or early stage clinical analysis. This sequencing necessitates a step-change beyond 2015, if there are significant leads and industry engagement. In both programmes there will be milestone hurdles and STOP/GO analysis.

Weaning Foods for Health is proposed to commence in mid-2016, subject to further development and analysis of the preliminary proposal. Research in F&B in the weaning transition was highly prioritised, with evidence of high impact and science stretch, yet the investment was dependent upon the collation and collaboration of research capability in the immunity/allergies areas. A full proposal is expected end 2015 for analysis.

COLLABORATION AND RESEARCH PLATFORMS

Across the prioritised research programmes significant synergies and collaborative activities will be achieved. Initially this is focused on key methodologies that accelerate the rate of discovery, analysis and validation.

HVN Platform Capabilities

Next Generation Sequencing

- *Next-generation sequencing technologies allow to quantitatively profile the complete transcriptome (inclusive of microRNAs) in increasingly smaller subsets of cell, tissues and blood samples.* Across the programmes HVN will coordinate sequencing access and the bioinformatics expertise to interrogate and convert large amount of sequencing data into applicable knowledge. This expertise is concentrated at AgResearch and Otago University.

Metabolomics

- *Metabolomics is the application of an un-biased, comprehensive chemical analysis to investigate of the full complement of metabolites contained within a biological system.* HVN will access the largest Metabolomics facility in NZ-Australia at AgResearch, equipped with 12 mass spectrometers, such as UHPLC-high resolution MS orbitraps, UHPLC-MS^n iontraps for metabolite identification, and both triple-quad LCMS and GCMS instruments for metabolite quantification, along with data-processing to mine and merge metabolomics data with other 'omics' platforms. Drs Karl Fraser and Jan Huege (AgResearch) will provide leadership with the use of this platform.

Proteomics

- *Proteomics provides information on proteins, including their relative abundance, distribution, posttranslational modifications, functions and interactions with other macromolecules in a biological system.* HVN will access differential proteomics using 2D-DIGE and iontrap MS protein identification, targeted biomarker quantitation using triple quad-trap detection, global proteomics and imaging mass spectrometry using state of the art TOF/TOF instruments. Drs Janine Cooney and Stefan Clerens (PFR) will provide leadership with the use of this platform for HVN.

Systems analysis

- *Systems analysis (e.g. Ingenuity Pathway Analysis (IPA), mixOmics, and metaCyc) enables key insights into experimental data by identifying relationships, functions and pathways of relevance, and can predict the cause and effects of changes in expression through transcription factor activation or inhibition*. HVN will have access to a systems analysis platform to accurately define target phenotypes, and to better understand the complexity of the biological response to foods. This expertise is concentrated at AgResearch and Otago University.

Microbiota

- *An ever-increasing body of evidence now exists showing that the microbiota functionality is primordial to understand how the host and the microbiota interact in term of a food-health relationship.* HVN will have access to bioinformatics expertise (e.g. Qiime 1.8 and MG-RAST) that convert large amount of sequencing data on microbial function (shotgun sequencing of metagenomic DNA and meta-transcriptomic RNA using the Illumina

Hi-Seq platform) and microbial profiling (pyrotag sequencing of bacterial 16S rRNA gene amplicons) into knowledge. This expertise is concentrated at AgResearch and Otago University.

Immunophenotyping and Inflammation

- *Dynamic immune responses are relevant indicators of the ability to maintain inflammatory homeostasis.* HVN will have access to the Malaghan Institute multi-parametric flow cytometry to assess cell number and frequency, activation status and cytokine production in peripheral blood and single cell suspensions generated from tissue samples from pre-clinical and clinical studies. Further, ELISA, ELISpot and multiplex assay platforms to assess cytokine and chemokine. Dr Elizabeth Forbes-Blom will provide leadership in the use of this expertise.

The development of clinical platforms, including the registration, standard operating protocols (SOPs) and external auditing will be developed during 2015.

INDUSTRY ENGAGEMENT

To date there has only been high level industry endorsement, without detailed science-business interaction to develop an effective knowledge exchange to refine and further focus the research directions within each programme.

In the first half of 2015, prior to HVN approval of the final investments for contracting engagement and greater validation from F&B organisations willing to engage in the specific consumer health target areas covered by our Priority Research programmes. This will be achieved by:

1. Joint working group meetings with F&B businesses and the Expert Groups (from March 2015) to workshop the proposed research. This will have the benefits of providing further insights into the potential business opportunities arising from the proposed research and enable those businesses to consider product development and early strategy for potential pathways to market. The ability of businesses to inform and input into the research programmes is also vital, this knowledge, skill and investments possible from businesses into the proposed programmes.
2. Focused engagement with Maori F&B business leaders to identify and incorporate opportunities for Maori businesses.

REGULATORY PATHWAY

The regulatory landscape of the research programmes is a key consideration that will need to be considered at the commencement and dynamically as the research progresses. The establishment of clear (and early) sequenced pathway towards a successfully substantiated health claim, taking into account the level standards of evidence, the application of proxy measures of health status (biomarkers) and the level of health claim (general level/high level) is vital for further refining the research focus. Beyond FSANZ regulation, establishing effective and ongoing dialogue with the NZ Ministry of Primary Industries (MPI) will inform on the international equivalence of the proposed route to and content of the FSANZ health claim (Appendix 9).

ALIGNMENT AND CO-INVESTMENT

Further potential dynamism of the prioritised research programmes can be achieved with CRI Core funding alignment and co-investment. The current (Appendix 8) and subsequent annual CRI Core investment process can enable further analysis and prioritisation of HVN research programmes to accelerate and enhance outcomes.

APPROVAL AND REVIEW

These processes will enable refinement of prioritised research programmes prior to confirming investments. The definitions of milestones and the outcomes to ensure they are measurable and able to deliver against the HVN mission.

ANNUAL SCIENCE FORUM

Commencing in 2016, HVN will host a annual science forum that will present and showcase the science achievements and outcomes of HVN. This science forum will include both keynote presentations through to sessions run for students and early career researchers. Thematic sessions focusing on technology and platforms will augment this science program. This will be aligned with a meeting of the Science Advisory Panel (SAP) with these distinguished scientists able to chair sessions and give presentations. This meeting will be open to both scientists and New Zealand F&B representatives.

BUSINESS PLAN

PARTNERING FOR SUCCESS

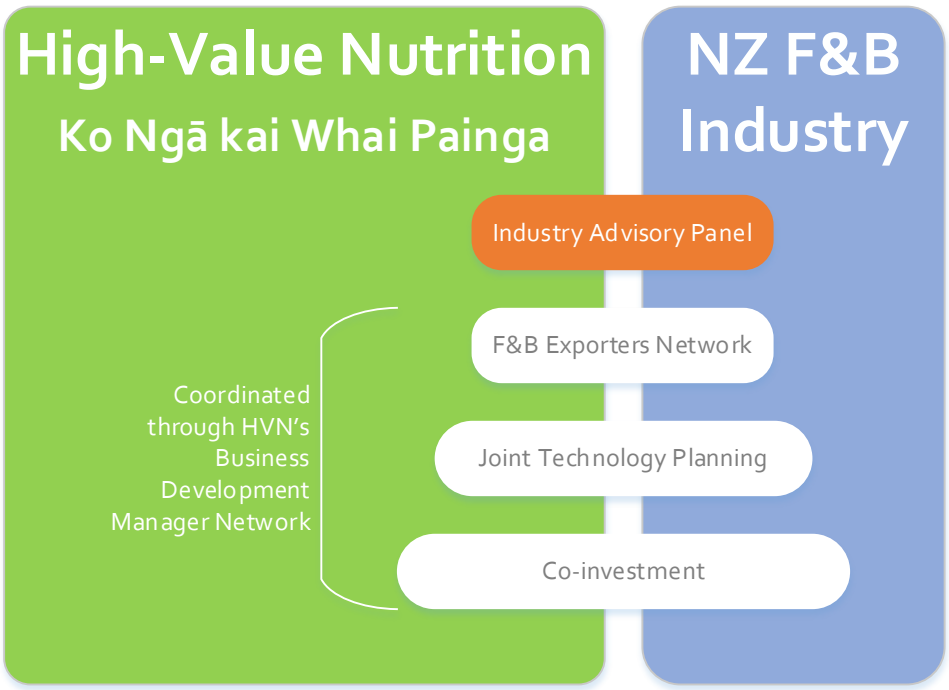
Building an effective network that will increase impact

To achieve the link between desired impacts and research outcomes, HVN is building strong and effective relationships. Those relationships are critical for a virtual centre that sits across industry and multiple research organisations.

STAKEHOLDER AND INDUSTRY ENGAGEMENT

HVN has a clear economic mission and therefore needs to ensure both its upstream research investments are relevant, of high quality and timely, but also have effective mechanisms in place to engage with interested and aligned businesses. Those engagement mechanisms facilitate research commercialisation and ensure the downstream capital investment is made to drive economic outcomes. It is this necessary relationship that HVN is building through a multiple level engagement model supporting our roles of:

- Aggregating, integrating and communicating scientific knowledge relevant to the priority consumer health targets.
- Developing pathways for research translation and engagement to enable New Zealand industry to increase economic returns through the development and marketing of evidence based health foods.



THE F&B EXPORTERS NETWORK

HVN is developing a network of aligned businesses to deliver the following activities and benefits:

- Access to authoritative information and experts on food, nutrition and health/wellbeing relevant to their business strategy including targeted workshops in areas of interest to network members;.
- Ability to influence research directions to align with their commercial requirements;
- Expanding the perspective of businesses as to how the science of food health relationships can drive value creation for them;
- First look at research findings and access to unencumbered novel intellectual property;
- Sharing learnings from marketing foods and beverages with health benefits and best practice across the network including a forum to present their work.

The value HVN derives from the network is knowledge of what businesses need to be successful in marketing F&B products with health/wellbeing benefits, likely areas for focusing the research and generic consumer and market insights.

The HVN F&B Exporters Network (FBEN) was inaugurated through a forum held in Auckland in November with over 90 registered attendees including from over 40 F&B businesses (please see feedback survey results in Appendix 6). Feedback from the forum indicated a strong support to the Challenge's mission and its consumer-centric strategy as well as a willingness to be engaged in the development and focussing of the long term science programmes. This greater level of engagement will commence in early 2015 through establishing working groups of interested businesses with each of our Priority Research programmes – these working groups will aid in the validation and refinement of the programmes prior to contracting and will ensure they are well aligned with industry needs and realities.

These will be group activities where businesses engage with the HVN programmes in a collective mode. One-on-one engagements will either be brokered via our Business Development Managers Network or the Joint Technology Planning process outlined below.

It is planned that an Annual Stakeholder Forum will collectively engage the FBEN and BDMN to interconnect the knowledge and insights from science to industry and industry to science, with the aim of advancing the HVN mission.

THE BUSINESS DEVELOPMENT MANAGERS NETWORK

Without being a legal entity in its own right HVN can only carry out transactional business activities via its collaborating parties. All have assigned Business Development Managers to work with HVN and form the core of the Business Development Managers Network (BMDN). The Challenge is also inviting other research organisations that have an active interest in the Challenge to join the network to ensure access to the relevant research capabilities in New Zealand. The inclusion of the Cawthron Institute is likely to be followed by other research organisations.

Table 9 - Business Development Managers Network

 Nick Reilly - UniServices	 Kevin Argyle – AgResearch
 Cath Kingston - Plant & Food Research	 Mark Cleaver - Massey
 Mary Gower - Otago	 Katy Bluett - Callaghan Innovation
 Craig Armstrong - NZTE	 Augusta van Wijk - Cawthron Institute

The network's operating model is that any contact from a New Zealand based F&B business to any member of the HVN BDMN seeking HVN relevant research capabilities or information will be treated as an HVN client on behalf of the network. The BDM contacted and the Directorate will jointly develop the appropriate and best response for the business from across the network (i.e. a no wrong doors/ best team/ single point of contact and a single contract model). This could involve arranging a multiparty response and coordinating its delivery to the client via a single point of contact, a cross referral to the right party to handle or whatever works best for the business client.

This would be the standard level of engagement for businesses wanting technical and scientific services from the HVN collaboration in a responsive mode. It would operate under the HVN brand rather than individual party brands.

JOINT TECHNOLOGY PLANNING PROCESS

A successful approach used within other industry facing research collaborations in New Zealand, such as the Product Accelerator and Food HQ, is to offer a joint technology planning (JTP) service to leading innovative F&B businesses. The principle is to define together scientific and commercial goals at the inception of the journey towards capturing an opportunity to maximise its probability of success.

Process for Joint Technology Planning

1- Preliminary meeting between the HVN management team with senior executives of the business to confirm the parameters and focus for the JTP.
2- Under confidentiality agreement, the key business people including their marketers, technical/R&D people, manufacturers/product people and senior executives then engage in a two way learning process with experts from across the HVN collaboration. The business shares its market and consumer insights, describes its capabilities, business aspirations, critical timeframes and strategy, while HVN describes the current state of science and technologies and the potential for research driven business solutions. This results in the identification of well-defined business opportunities with clear value propositions that are attractive to the business and need science input to come to fruition.
3- Agree the lead research party to work with the business to develop an investment proposal which accesses the collective capability from the HVN network.
4- Contract commercial research or seek government funding in whole or part via Callaghan Innovation schemes.
5- Once funded the Lead Party agrees a single research contract with the business and arrange the subcontracting across the HVN network as required, to maintain a single point of contact with the business.

This is the proactive mode of industry engagement and as well as facilitating technology transfer to businesses would also facilitate market and business knowledge transfer to HVN. Again the activity would occur under the HVN brand rather than individual institution brands. Any co-funding from third parties would be managed by the lead party and not enter the HVN accounts apart from any JTP service fees which would be managed centrally by HVN.

BUSINESS INVESTMENT IN PRE-COMPETITIVE RESEARCH PROGRAMMES

HVN has identified more opportunities than it can support through its Priority Research funding. This leaves strong investment options unsupported in the first funding period (ending 2019). Outcomes from the Priority Research can be also brought into fruition quicker through broadening the funding pool.

HVN will:

- Invite interest from industry in co-investment in pre-competitive Priority Research programmes – either to accelerate their progress, expand their scope or pick up additional unsupported investment options.

This level of engagement implies that such co-investments will come under the control of HVN and thus be subject to direct governance oversight by the HVN Board.

INTELLECTUAL PROPERTY MANAGEMENT AND COMMERCIALISATION

The HVN parties have agreed to both the principles and practises for the protection and commercialisation of intellectual property (IP) created from HVN investments ("Project IP"). The IP Management Plan is presented in Appendix 10. It is based on the underlying principle that HVN is to create benefit for NZ by achieving its mission.

Project IP will, to the extent reasonable, be commercialised by the owning/managing party in a manner consistent with this purpose. Such commercialisation may involve making the Project IP available to a suitable NZ company, or publicly disseminating the Project IP.

As HVN is not a legal entity it will not own Intellectual Property, consequently:

- Research organisations participating in the Challenge retain ownership of both Background IP and new Project IP created;
- Where multiple parties create IP then it is up to them to agree IP arrangements but the Challenge will have visibility of the outcomes of these discussions;
- Research organisations do their own technology transfer or commercialisation;
- Where private businesses are involved in the creation and commercialisation of Project IP then the parties agree the IP and commercialisation arrangements which should be consistent with achieving the mission of HVN.

COMMUNICATIONS/MARKETING AND OUTREACH

A clear expectation from government is that National Science Challenges will engage stakeholders and the public in the role of science in addressing critical issues for the future benefit of New Zealand. This requires an active approach to communicating to these various audiences. HVN's communications objectives are to:

- Support the creation of HVN's identity to the various stakeholder groups;
- Support the establishment of HVN's "authoritative voice on food for health claims" by building our credibility in terms of science excellence, nationally and internationally;
- Facilitate engagement across partners and the NZ science sector as well as engagement with industry and government.

The role of communications is closely linked to the expectations of creating a recognised "centre of excellence" for food-for-health which encompasses:

- The ability to rally and lead the national research agenda;
- Engage with national and international food regulators;
- Outreach through technical communications, with opinion articles, statements of evidence, systematic reviews and other publications that encompass the science activities of HVN and the broader food & health environment;
- Marketing and communicating HVN as the one-stop-shop with regards to food-for-health for industry;
- Transferring knowledge to industry effectively.

There is a significant expectation for the NSCs in general to play a prominent national role in promoting science to the public and HVN is expecting to work across the NSCs and other major science initiatives such as CoREs and take a coordinated and efficient approach.

HVN is implementing a multi-tiered approach to communicating with the diverse set of stakeholders engaged with the mission of HVN (researchers, and research organisations, F&B businesses, government agencies and other interested parties) using subscription-based newsletters, web, social media and events. HVN will hold two major events annually – a science symposium to present progress and ensure open discussion of the science and a F&B exporters network forum to maintain ongoing engagement with interested and aligned businesses. HVN is also investigating holding an international science conference – most probably every two years.

Complementing generic communications requirements will be technical knowledge transfer and technical communications. This will be an important opportunity for quick wins and also for providing business friendly and authoritative information of relevant food-health relationships – based on current international science as well as HVN research, and this is will be resourced accordingly.

OPERATIONAL EXCELLENCE

Building a world-class Centre of Excellence

OPERATIONS AND BUSINESS PROCESSES

The HVN Board and directorate have implemented robust business processes during the establishment phase.

HVN processes

- Board meetings – with standard review of conflicts register, approval of minutes, financial reporting, review of progress against plan and scrutiny and approval of management recommendations for all matters pertaining to the development of the HVN research and business plans.
- SLT and Expert Panel meetings to develop the research plan.
- The IAP has met twice during the establishment phase to assist in the positioning of HVN to generate economic outcomes and advise on our approach to industry engagement.
- The BDMN has also met twice during the Establishment phase and has assisted in the development of the industry engagement and commercialisation model as well as reviewing this business plan).
- F&B Exporters Network forum.
- Stakeholder communications.
- Collaborating Party management meetings, HVN has established direct management communication channels with each party to the Collaboration Agreement for HVN with initial meetings held to clarify the focus for these meetings as distinct from Board level or SLT level interactions.
- Contracting processes via the University of Auckland Research Office to MBIE and related establishment of internal project accounting to monitor HVN finances.
- Subcontracting to Challenge Members and other parties using a template agreed within the Collaboration Agreement.
- Recruitment of HVN head office roles and procurement of goods and services within the University's procurement policies and under an approved HVN Board budget and financial delegations.

HVN has implemented a robust investment framework with prioritisation criteria and processes to inform Board decisions on research investments. HVN is conscious that NSCs are operating as devolved public funding agencies with the potential for external scrutiny that requires considerable care in how such decisions are made.

HVN will develop in 2015 both Requests for Proposal and Closed Tender (or alternative contracting mechanisms) processes for Contestable and Priority Research Programme and Research Project funding respectively. Contingency funding will be via a Board approved process.

DRIVING PERFORMANCE

HVN has a number of roles to play to fulfil the government's expectations and achieve its mission but they can be simplified down to investing in research and related activities to create the integrator role and knowledge basis for achieving economic impact.

HVN's performance management system has to consider:

- The performance of the actual research activities against investment expectations;
- The wider performance and progression of the Challenge towards achieving its mission.

These two elements will be considered separately here.

MANAGING RESEARCH INVESTMENTS

Defining clear expectations

All research investments made by HVN will via subcontracts approved by the Board. Effective performance management of research investments will require that the expectations for subcontracts are clearly specified in a way that is aligned with the mission. It will involve the key elements below, which the Challenge will ensure are in place through subcontracts negotiation.

- Research Objectives – must state the intended results of the piece of research in a way that described its contribution or progress towards the mission (as opposed to an open investigation).
- Milestones – must define a critical achievement in the pathway to achieving the Research Objective without which the Research Objective cannot be achieved. Milestones must be time bound, failable and independently verifiable.
- Defined End-points – must be the description of successful achievement of the research objective in a quantitative way that describes progress towards the mission. In other words it should define the parameters for assessing success. As with milestones it must be time bound, failable and independently verifiable.

Reviewing performance

It is through the reporting mechanism that HVN will be able to gather the data needed to both assess performance and manage the investments, but also satisfy MBIE's expectations. MBIE will require an annual report in July each year as well as an annual plan in May. To support these processes HVN will have a second subcontract report at a mid-year point to ensure subcontracts are on track prior to the reporting to MBIE. The two reports will have the following emphasis:

- Mid-year report – focus on Objectives, milestones and endpoints only.
- Year-end report – in addition to reporting on the objectives, milestones and endpoints include all the other qualitative and quantitative data required for both MBIEs annual report and any other performance monitoring requirements set by the HVN Board.

To ensure subcontracts are performing to plan HVN will review and manage performance in a systematic way:

- Mid-year reports will be reviewed by HVN Directorate to clarify any ambiguity in the reports against milestones and endpoints that were due in the period.
- Year-end reports will be given a greater degree of scrutiny as they form the basis of reporting to MBIE as well as the Board. In addition to the scrutiny of due milestones and endpoints these reports will also be reviewed by two independent members of the SLT.
- A third level of review will occur at the end of a subcontract to assess its overall performance. This will involve members of the SLT with one or two fully independent external reviewers. Their report will go to both the subcontracting party and the HVN Board via the Director and be a consideration in deciding on any future investments, and will also be used in determining if the final payment will be made (see below).

Managing change

HVN requires a dynamic approach to performance management to adjust to the realities of an uncertain activity such as research.

In simple terms the Challenge will use a reforecasting and contract variation approach to adjust for the uncertain path that research takes. Thus if a milestone is off track (either delayed or modified in some way)

then it can be reforecasted and/or revised by request of the subcontractor and by approval of the Director. If the Director believes these changes put the successful achievement of any Research Objective and defined End-point at risk it will be escalated to the Board for approval and any consequences considered.

Financial incentive

Research contracts will have an agreed payments schedule, quarterly in advance, with the final quarterly payment held back until the final report is received and the end-point assessed as achieved by the review process. The final payment will be released upon approval from the HVN Board. This will put sufficient funds at risk to maintain incentives on the subcontractor to ensure best endeavours are made to perform.

MANAGING THE CHALLENGE'S PROGRESS AGAINST ACHIEVING THE MISSION

MBIE is developing a performance management framework for all the National Science Challenges based on a standard policy intervention logic model. HVN has been working with the ministry to develop this framework and adapt it to this Challenge. The approach taken by MBIE has three distinct elements – Challenge specific indicators; generic NSC performance areas (and performance indicators); and general statistical information.

HVN has worked with the ministry to develop a draft HVN specific framework with a suite of HVN performance indicators and aspirational targets that cover the progression from activities and outputs to short, medium and long term outcomes aligned with the HVN vision/mission and our intended impacts (see diagram 1). In addition to these MBIE are finalising a further suite of six key performance areas applicable to all NSCs (Appendix 11).

THE KEY PERFORMANCE INDICATOR

Value of export revenues from discrete F&B products supported by evidence dossiers based on "HVN" research demonstrating health benefits for consumers.

THE ASPIRATIONAL TARGET

>$1b p.a. in additional F&B export revenue by 2025.

QUALITATIVE EXPERT REVIEW

Complementarily to metrics, HVN intends to use qualitative reviews by independent experts at appropriate timeframes. These reviews will be able to draw on the quantitative measures collected annually but also look at the quality of the content.

HVN intends to space such evaluative reviews over the term of the Challenge with the first in early 2019, prior to the second contract period, a second in 2022 and the final review in late 2024 after the end of the second contract period. Sensibly the reviews could be coordinated by MBIE (with HVN Board input) and draw from members of the original assessment panel as well as the HVN Science and Industry Advisory Panels to ensure continuity of assessment over time. As well as the annual reports and quantitative data described above, a special report could be prepared for each review outlining in more descriptive terms what has been achieved and the pathway to the mission and ultimately impact with recommendations to improve performance.

BETTER ASSESSING IMPACT

Although HVN's aspirational target is to contribute to economic growth by $1b pa in new export revenues by 2025, the Challenge has limited knowledge to base that target on, and it is common sense that such achievement will be due to a complex set of factors.

To provide better evidence for setting and monitoring the impact of HVN (or its successors), the Challenge intends to invest in the development of a measurement system for tracking F&B export revenues and linking them to validated health benefits and in some cases regulatory approved food-health claims. This could then be linked further back to any supporting research or research capabilities and so the relationship between HVN (and related) investments and the downstream impact or economic outcomes established. This will be funded from the Special Projects budget category and will be initiated post contracting via an open tender process.

FINANCIAL MANAGEMENT, ADMINISTRATION AND OVERSIGHT

The parties to the Challenge are all significant research organisations with a long history of financial stability in New Zealand and considerable experience in the management of public research funds. Each is independently audited for the use of such funds according to the standards of the Office of the Auditor General and Controller. The funds for HVN will be managed on behalf of the Parties by the University of Auckland.

The University of Auckland will establish discrete accounts within its financial management system for HVN funds and distribute funds to the parties (and other research organisations in New Zealand or overseas) via standard subcontracts using a template specifically designed for the Challenge. Any HVN research funding directed to the University of Auckland will be transferred to dedicated project accounts established on an equivalent basis to external subcontracts.

Expenditure of funds within University of Auckland accounts will be according to its internal delegations and procurement policies with the additional requirement that all internal and external expenditure will be subject to HVN Board approval (or under a Board approved delegation). The University of Auckland will monitor funds for any unusual expenditure and provide regular financial reporting on the use of funds to the Director and the HVN Board.

The HVN Directorate will be able to leverage the University of Auckland's financial management, research project management (including subcontracting), IT, HR and other internal systems and infrastructure.

While all treasury functions are provided by the University of Auckland for HVN and financial administration is within their policies and practices the HVN Board will have full oversight of the financial performance of the Challenge and approve all HVN level budgets and expenditure against those budgets. The Board has already established financial delegations to the Director to authorise non-research expenditure with any personal expenditure by the Director being approved within the University system (i.e. via line manager) and reported to the Chair. All research funding decisions will be made by the full Board and then enacted by management via the research administration systems in place within the University of Auckland.

The resourcing model and budget (Appendix 1) is described in the next section and has been phased to align with HVN's expectations on how the Challenge will develop over time. The investment profile increases as the Challenge completes strategic analysis and science planning processes, contract Priority Research and run contestable processes, and decreases once approaching the second funding period.

Following approval the annual cash flow profile will be broken down to a quarterly projected cash flow which will be included in the payments schedule from MBIE to the University of Auckland for the HVN Challenge to invest.

RESOURCING AND BUDGET

The HVN Challenge will demonstrate national leadership and be involved in all aspects of achieving its mission and the roles that that implies (as outlined in the overview section). HVN will operate as a robust devolved funding agency with sound governance, management and business processes. The Science Board feedback was also explicit in recommending that the Directorate should include a dedicated commercialisation and industry engagement specialist and regulatory expertise in addition to using the commercialisation capability residing in the partner organisations. Our resourcing plan and resulting budget have aimed at achieving a balance between the resourcing of these functions and services and the investment in research as outlined below.

Table 10 - Resourcing

Governance and Advisory	
A key expectation of the National Science Challenges is for strong and independent governance supported by high quality industry and international science advisory panels. This requires budgeting for the direct costs of the independent members of the Board (fees assumed at $25k Chair and $10k others x3) plus estimated travel and accommodation costs for an annual meeting of the international Science Advisory Panel. No fees are included for SAP or IAP members.	
National Science Leadership	
HVN has established a mixed model with both central national leadership/management supported by a distributed science leadership model. This involves the Director and seven members of a Science Leadership Team being involved in critical business processes including monitoring and reviewing research performance, supporting annual reporting and planning, assessing contestable proposals and acting as ambassadors to the Challenge.	
• Director	up to 1 FTE
• Science Leadership Team	0.05 FTE x 7
Industry Liaison and Commercialisation	
HVN's approach to industry engagement is based around a no-wrong-door collaborative and decentralised model in which businesses may approach any one of the parties via the BDMN who will triage on behalf of the Challenge and work with the network to provide a solution for the business. HVN intends to resource this function to ensure effective implementation and coordination of the model.	
• Industry Engagement Manager	0.5 FTE
Communications, Marketing and Outreach	
There is a significant expectation for the NSCs in general to play a prominent national role in promoting science to the public. On top of this generic communications requirement is a need for technical knowledge transfer and technical communications. This is strongly linked to the need to have regulatory expertise in health food claims within the Challenge and will be best met by recruitment of a professional nutritionist with regulatory and communications experiences from industry or public health agencies. These two related functions have been budgeted as two half time roles coming on board during the first funding period.	
• Marketing & Communications Manager	0.5 FTE
• Nutrition & Regulatory Specialist	0.5 FTE
Administration, Management and Operations	
This includes office administration and management, accounts and purchasing, arranging travel and accommodation (across all functions), secretarial services to the Board, administrative services to the Director, operations management including all business process relating to funding (priority, contestable and contingency funding processes, subcontracting, monitoring and managing performance and reporting), Board and Advisory processes and contract management with MBIE (note these are only elements beyond standard services provided by the University of Auckland as host). These activities operate at two levels – an administrative level and a professional operations management level.	
• Coordinator	1.0 FTE
• Operations Manager	0.3 FTE

These resourcing requirements have been included within the overall budget outlined in Appendix 1

RESEARCH INVESTMENTS

The budget model in Appendix 1 outlines the projected cash flow for the investment of research funds via Priority Research Programmes, Contestable Research Projects, Special Projects and Contingency investments. It has assumes a gradual build up in research activities in the first funding period as Priority Research Programmes are confirmed and established and the first Contestable Funding round completed. It is also based on these investments completing around year end 2018 to allow for performance and strategic reviews as inputs to the planning for the second funding period from 2019 to 2024.

BUDGET MODEL

HVN has developed a detailed budget to support the resourcing model outlined above with year by year cash flow for the funding period to mid-2019 and then average indicative costs for the final funding period to mid-2024. This is presented in the spreadsheet in Appendix 1, and is based on full cost funding principles and relates specifically to the funds available to the Challenge from MBIE.

The indicative budget does not include any related or co-funding from third parties (including aligned CRI core funding) as this is not received by HVN but rather retained by each of the parties. Such related funding will be reported separately to MBIE to keep a clear differentiation between funding provided for HVN and that received separately by the parties.

APPENDICES

Appendix 1 – HVN Budget

Budget for HVN NSC

Assumes 1 July to 30 June year

Budget Category	First funding period (4.5 years) Q2-3 2015	15/16	16/17	17/18	18/19	Total $000's	%	Second Funding Period 2019/2024 (five full years) Average pa $000's	%	Total $000's	%
EXPENDITURE											
A. Central Administration and Management											
Coordinator 1.0 FTE at $65K p.a. plus related and indirect costs	0	140	142	145	148	$575k	1.9%	$ 150	1.41%	$ 750	1.42%
Operations Manager 0.3 FTE at $95k p.a. plus related and indirect costs	50	65	67	69	71	$322k	1.1%	$ 74	0.70%	$ 370	0.70%
General Administration /Office/Travel/Meeting/Accomodation costs etc	5	75	75	75	75	$305k	1.0%	$ 110	1.03%	$ 550	1.04%
Subtotal						**$1,202k**	**4.0%**	**$ 334**	**3.14%**	**$ 1,670**	**3.15%**
Uncharged direct roles (0.5 Administrator/ 0.5 Accountant)	*35*	*101*	*102*	*105*	*108*	*$451k*		*$ 110*		*$ 550*	
B. Governance and Advisory											
Independent Board member fees	12.5	55	55	55	55	$233k	0.8%	$ 60	0.56%	$ 300	0.57%
(no fees but assumme an annual meeting in NZ with travel and accomodation)	0	35	35	35	35	$140k	0.5%	$ 30	0.28%	$ 150	0.28%
Subtotal						**$373k**	**1.2%**	**$ 90**	**0.85%**	**$ 450**	**0.85%**
Uncharged Board members fees	*12.5*	*25*	*25*	*25*	*25*	*$113k*		*$ 25*		*$ 125*	
C. Communications, Marketing and Outreach											
Nutrition and Regulatory Specialist 0.5 FTE at $120k pa plus related and indirect costs	0	131	131	131	131	$524k	1.7%	$ 135	1.27%	$ 675	1.27%
Marketing & Communications Manager 0.5 FTE at $80k p.a. plus realted and indirect costs	50	88	90	92	95	$365k	1.2%	$ 100	0.94%	$ 500	0.94%
Publishing costs	0		15	15	15	$45k	0.2%	$ 35	0.33%	$ 175	0.33%
Event costs (assume 2 events pa - one industry forum and one research symposium)	0	40	40	40	20	$140k	0.5%	$ 45	0.42%	$ 225	0.42%
Subtotal						**$1,074k**	**3.6%**	**$ 315**	**2.96%**	**$ 1,575**	**2.97%**
D. Industry Liaison and Commercialisation											
Industry Engagement Manager 0.5 FTE at $150k p.a. plus related and indirect costs	0	160	160	165	170	$655k	2.2%	$ 170	1.60%	$ 850	1.60%
Industry engagement related expences		5	5	5	5	$20k	0.1%	$ 10	0.09%	$ 50	0.09%
Subtotal						**$675k**	**2.3%**	**$ 180.00**	**1.69%**	**$ 900.00**	**1.70%**
Uncharged Business Development Managers fees estimate		*100*	*100*	*100*	*100*	*$400k*		*$ 100.00*		*$ 500.00*	
E. Science Leadership and Discretionary											
Director 1.0 FTE at $240K p.a. plus related and indirect costs	100	515	520	525	530	$2,190k	7.3%	$ 540	5.08%	$ 2,700	5.09%
Science Leaders Group (up to 7 x 0.05FTE (assuming $180k pa average salary) plus related and indirect costs)	0	132	136	140	144	$552k	1.8%	$ 160	1.50%	$ 800	1.51%
Subtotal						**$2,742k**	**9.1%**	**$ 700**	**6.58%**	**$ 3,500**	**6.60%**
Uncharged SLT time estimate		*132*	*136*	*140*	*144*	*$552k*		*$ 150*		*$ 750*	
F. Research Funding											
Priority Research Programmes	0	3500	4500	4500	2000	$14,500k	48.3%	$ 5,300	49.81%	$ 26,500	50.00%
Open Contestable Funding	0	1000	2500	2500	1000	$7,000k	23.3%	$ 2,800	26.32%	$ 14,000	26.42%
Special Projects		800	400	200	100	$1,500k	2.8%	$ 400	3.76%	$ 2,000	3.77%
Contingency Funds	0	200	250	250	250	$950k	1.1%	$ 500	4.70%	$ 2,500	4.72%
Subtotal	**265**	**7299**	**9484**	**9312**	**5221**	**$23,950k**	**79.8%**	**$ 9,000**	**84.59%**	**$ 45,000**	**84.91%**
TOTAL						**$30,016k**	**100.1%**	**$ 10,619**	**99.8%**	**$ 53,095**	**100.2%**
Total Uncharged Costs estimate	***47.5***	***358***	***363***	***370***	***377***	***$1,516k***		***$ 385***		***$ 1,925***	
NET REVENUE - EXPENDITURE						**-$16k**	**-0.1%**			**$ 105**	**0.2%**
Funds Available First Period (2015/2018)						**$30,000k**					
Funds Available Second Period (2018/2023)						**$53,200k**					
GRAND TOTAL						**$83,200k**					

Note: all related costs have been budgeted at 7% of salary costs and indirect costs (ie overheads) have been budgetted at 111% of salary.

Appendix 2 - Profiles of Board Members

Member	Relevant skills and experience										
	Clinical Nutrition	Public Health	Research Ethics	Food Regulations (incl. health claims)	Food export & marketing	Research Strategy, Management and Performance	Science of nutrition and health	NZ food sectors	Maori Engagement	Governance and Risk management
Chair (Independent)										
Bob Major					Yes	Yes		Yes		Yes
HVN Partners										
Professor Warren McNabb				Yes	Yes	Yes	Yes	Yes		Yes
Dr Jocelyn Eason				Yes	Yes	Yes	Yes	Yes		Yes
Professor Jane Harding	Yes	Yes	Yes			Yes	Yes			Yes
Professor Brigid Heywood			Yes			Yes				Yes
Professor Christine Winterbourn						Yes	Yes			
Independents										
Jane Lancaster				Yes		Yes				Yes
Mavis Mullins		Yes	Yes					Yes	Yes	Yes
Paul Morgan					Yes			Yes	Yes	Yes

Bob Major- Independent Director

Mr Major holds a Master's degree in Science from Massey University. He has spent the majority of his career in various roles within the New Zealand dairy industry, working for the New Zealand Dairy Research Institute, the New Zealand Dairy Board and Fonterra Co-operative Group. He has held global leadership roles for Fonterra in a number of areas including strategy, mergers and acquisitions, ingredients sales and marketing and innovation. He also held regional leadership roles in the Middle East, Hong Kong and China and was on the senior leadership team of both the New Zealand Dairy Board and Fonterra.

Mr Major has been a director of a number of New Zealand industry-good organisations, as well as of various Fonterra subsidiaries and joint ventures in Europe and Asia. He is now a professional director and is Chairman of The Mud House Wine Group, and a Director of Sealord Group, Barker Fruit Processors Ltd, Westland Co-operative Dairy Company and BioVittoria Ltd. He is a member of the International Development Advisory and Selection Panel, appointed by MFAT to provide advice on the New Zealand Aid Programme's direction, priorities, and approaches to development and to review applications to the Sustainable Development Fund.

Jane E Harding ONZM MBChB DPhil FRACP FRSNZ

Distinguished Professor Harding is Deputy Vice-Chancellor (Research) of The University of Auckland, a researcher in the Fetal and Neonatal Physiology research group of the University's Liggins Institute. Her training included a medical degree at the University of Auckland, a D Phil at the University of Oxford, and a postdoctoral Fogarty Fellowship at the University of California at San Francisco.

Professor Harding has undertaken teaching and research at The University of Auckland for much of her career. In her current role, she has overall responsibility for the University's research activities. She is also a paediatrician, and until recently practised as specialist neonatologist, caring for new-born babies at National Women's Hospital. Her ongoing research activities concern the role of nutrition and growth factors in the regulation of growth before and after birth, and the long-term consequences of treatments given around the time of birth.

Professor Harding has served on a range of national and international academies and bodies including those of the Health Research Council of New Zealand, National Health and Medical Research Council of Australia, Royal Australasian College of Physicians, and the Council of the International Society for the Developmental Origins of Health and Disease.

She was elected a Fellow of the Royal Society of New Zealand in 2001 and was made an Officer of the New Zealand Order of Merit in 2002. In 2004 North & South magazine made her joint New Zealander of the Year.

Jocelyn Eason BSc (Hons), PhD, MBA

Dr Jocelyn Eason has 23 years as a practicing researcher with over 30 peer-reviewed publications. She has a PhD in Plant Physiology from the University of Otago, an MBA from Massey University, and is a member of the Institute of Directors. Jocelyn's recent activities include developing and implementing a NPD mechanism for premium vegetable products, launching nutrition- and health benefit-labelled fresh vegetable products for the New Zealand market (vitalvegetables ng)a implementi communication strategy for nutrition and health benefits of vegetables in Australia (www.veggycation.com.au), developing a mechanism to manage investment in science, and implementing both Government and commercially funded research programmes.

As General Manager Science Food Innovation at Plant & Food Research, she manages 130 scientists that investigate human responses to food, the influence of food on human nutrition and wellness and the production of nutritionally-rich foods. The research conducted in the Food Innovation Portfolio focuses on horticultural and arable crops, working with primary industry bodies and food and beverage companies, both in New Zealand and internationally, to deliver premium food products. The science teams have scientific expertise in consumer insights, postharvest quality and traceability, food safety and packaging, food-health

relationships, bioresource engineering, biological chemistry, bioactive discovery and food evaluation.

Jocelyn is a member of PFR's Investment Committee, which is responsible for prioritising the CRI's $43m of core funding.

Christine Winterbourn

Professor Christine Winterbourn is an Auckland University chemistry graduate who received her PhD in biochemistry from Massey University and has a personal chair in the Pathology Department, University of Otago, Christchurch. She is a principal investigator in the Centre for Free Radical Research and leads a group investigating the biochemistry of free radical reactions and the involvement of oxidants and antioxidants in health and disease. Her work encompasses mechanisms of antioxidant defence, understanding how white blood cells kill bacteria, and free radical involvement in cardiovascular and respiratory diseases. Professor Winterbourn has published more than 300 scientific papers. As well as receiving the 2011 Royal Society of New Zealand Rutherford Medal, she has received the NZ Association of Scientists' Marsden Medal, Massey University 75th Anniversary Medal, Society for Free Radical Research (Australasia) Distinguished Service Award, University of Otago Distinguished Research Medal and Society for Free Radical Research (International) Lifetime Achievement Award. She has served as a member of the Health Research Council and of the Marsden Fund Council, is a Fellow of the Royal Society of New Zealand and a Companion of the NZ Order of Merit.

Mavis Mullins

Mavis is currently a company director, trustee and chairperson of several organisations and boards including chairing Poutama Trust, Atihau Whanganui Incorporation and Hautaki Limited. Mavis is also a director of 2degrees mobile, Taratahi Agricultural Training and Paewai Mullins Shearing Ltd. She is an Iwi negotiator for the Rangitane Tamaki nui a Rua and Wairarapa Treaty Settlement. Past directorships include Landcorp Farming, Massey University and two District Health Boards. She is patron of AgriWomens Development Trust.

Areas of interest lie in the land based primary sector, rural leadership development and Maori economic development.

Prof Warren McNabb

Warren was appointed Research Director for AgResearch in June 2011. He is an Adjunct Professor in the Riddet Institute, Massey University and is a Fellow of the New Zealand Institute of Agricultural and Horticultural Sciences. Warren joined AgResearch in 1993 as Senior Research Scientist in the Nutrition and Behaviour Group, promoted to Eminent Research Scientist in 2004, then to General Manager of the Food & Textiles Group in 2009.

His recent research has focused on nutrigenomics and nutritional epigenetics, and on food-host-microbial interactions and food for human health and wellbeing.

Jane Lancaster - Independent director

Jane has been active in research and innovation in New Zealand and internationally for 30 years specialising in commercial innovation in food, natural products and biotechnology. Jane has expertise in the regulatory systems for both new product development and exporting. She has consulted with Ministry of Agriculture and Forestry (MAF) and New Zealand Food Safety Authority (NZFSA) reviewing and designing product certification systems for NZ export industries. She has worked with many of New Zealand's leading companies in their business development, including working with ZESPRI International for five years as an Innovation Manager. Her education was at Canterbury University (B.Sc. Hons 1st class) and she is a professional member and certified practicing agriculturalist (CPAg) with New Zealand Institute of Agricultural Science and professional member of New Zealand Institute of Food Science and Technology. Jane is a director of AsureQuality. She was made a Member of the NZ Order of Merit (MNZM) in 2006.

Paul Morgan - Independent Director

Paul Te Poa Karoro has served as chair of Kono NZ LLP since 2011, and as chair of Kono's owner, Wakatu Incorporation, since 1986. Paul's career has been at the forefront of economic development for the Maori community for nearly 30 years, during this time he has had many directorships and roles with Government across agribusiness, science and business. Paul served as chief executive of the Federation of Maori Authorities, representing the interests of Maori business, from 1996 to 2007. He was awarded a QSO for services to Maori business in the New Years' Honours in 2010.

Paul as Chair of Wakatu Inc. has lead the evolution of the whanau business Kono NZ LLP a fully integrated business which, markets seafood, wine, horticultural produce and fruit leather from its lands and aquaculture farms in Te Tau Ihu, top South Island. Kono employs over 500 people with sales to 40 plus countries in the Kono brand. Paul in his capacity of Managing Director, Fomana Capital Ltd is currently involved with a range of other businesses and organisations spanning the nutraceutical, food ingredient, functional foods, cosmetics, aquaculture, food & beverage sectors and financial services.

Appendix 3 – Role of Board and Director

All Board members are bound (by signature) by a Terms of Reference which outlines their roles and responsibilities as defined in the Collaboration Agreement, via:

(a) Advising the Parties on the appointment of, and providing feedback on, the performance of the Director;
(b) Providing strategic, governance and business advice to the Director and the Challenge;
(c) Managing the risks of Director and Science Leadership Team bias or conflicts by reviewing and approving plans, reports and budgets;
(d) Raising the profile and reputation of the research and the Challenge;
(e) Providing oversight on the implementation and delivery of the Challenge work programme, its performance and the achievement of the outcomes envisaged in the NSC Investment Contract;
(f) Making decisions about allocation of Challenge Funding, the Challenge budget and other funding on the recommendation of the Director based on merit and alignment with the NSC Investment Contract and Principles;
(g) Approving recommendations from the Director on membership of the Science Leadership Team;
(h) Ensuring that the intent of the Collaboration Agreement, including the Principles, is upheld and no one Party is given an unfair advantage;
(i) Acting in a way that does not cause the Challenge Contractor to be in breach of the NSC Investment Contract;
(j) Ensuring any conflict of interest of any individual or Party is managed according to the Conflicts of Interest Policy outlined in Appendix 1 of the Collaboration Agreement;
(k) Meet regularly (at least annually) with the Science Leadership Team to build a shared vision and approach for the Challenge;
(l) Participate in reviews as required;

The roles for the Director are defined in the Collaboration Agreement as:

(a) Implement the NSC Investment Contract including any Challenge Programme Agreements on behalf of the Parties.
(b) Meet all reporting, review and record keeping requirements of the NSC Investment Contract.
(c) Report on all aspects of the management and research programme of the Challenge and of the NSC Investment Contract to the HVN Board.
(d) Coordinate, support and monitor management of the Subcontracts to the Parties and those internal projects funded from Challenge funds within the Challenge Contractor.
(e) Approve and monitor expenditure against the approved budget within delegated authority.
(f) Performance management of the overall programme of work to ensure the outcomes sought by the Ministry are achieved over the term of the NSC Investment Contract.
(g) Prepare, for approval by the HVN Board, any Annual Plans and budgets and any annual or other reports required under the NSC Investment Contract or any other documents as agreed by the HVN Board.
(h) Recommending to the HVN Board, on behalf of the Science Leadership Team, any decisions concerning allocation of Project Funding for Research and/or Related Activities under the NSC Investment Contract and this Agreement.
(i) Recommending to the HVN Board for approval any changes in Science Leadership Team members.
(j) Provide overall leadership of the research programme including promoting its value to external stakeholders.
(k) Provide input into performance management of business support and secretariat staff.

Appendix 4 - Criteria for research investment

IMPACT

#	Criteria	Sub-criteria
1	**Opportunity** - Scale and evidence of consumer demand for foods with the defined health benefits	• Scale of actual health or wellbeing deficit in significant population groups in NZ's target markets, preferably Asia/China, with estimates of potential market size. • Evidence of the needs and market size. • Evidence consumers' awareness and concerns about the health or wellbeing deficit. • Evidence consumers would respond to a nutritional solution (i.e. via food or beverage products) to improve the specific health/wellbeing deficit.
2	**Regulatory** - Potential for approval of marketable claims	• Evidence against FSANZ legislation that a claim is applicable • Evidence of potential in target export markets for claim equivalence.
3	**Industry** - Evidence of interest and support of New Zealand businesses	• Endorsement of target health/wellbeing benefits and potential nutritional solutions by NZ F&B businesses (requires several businesses expressing support and endorsement to score highly) • Evidence of business commitment to the programme via close engagement in the ongoing research including sharing of consumer insights, products for testing, parallel investment or development etc.
4	**Vision Mātauranga** - Addresses specific and distinctive needs and opportunities of Māori-owned F&B exporting businesses aligned with the HVN mission	
5	**NZ Inc.** - Fit with NZ Inc. strategy, resources and ability to capture benefits	• Evidence that NZ businesses can successfully operate in the target market • Evidence that New Zealand can develop proprietary products and capture significant market value (most likely via branded consumer products) • Evidence that New Zealand can develop acceptable products and supply the market based on existing resources

SCIENCE STRETCH

#	Criteria	Sub-criteria
1	**Science Excellence** - Assessment of overall research quality including design and methodology	• Extent to which the research proposed will be leading in the field internationally • Extent to which the methodology is appropriate and likely to result in new knowledge in the field of high scientific merit • Level of novelty of the approach
2	**Team** - Assessment of research team	• The breadth and depth of the research team that has been assembled • Evidence of the quality of the researchers and ability to perform the proposed research to a high standard
3	**Additionality** - Degree of collaboration, multidisciplinarity and integration of research themes and vision Mātauranga	• Evidence that the best team of researchers available nationally has been integrated into the proposed research • Evidence that the research will involve multi-disciplinary approaches that integrates the research across the four research themes to create novel outcomes that couldn't be achieved by discrete and narrowly defined projects • The extent to which vision Mātauranga based opportunities and approaches have been embedded within the research programme
4	**Capability** - Development of new and valuable research capabilities	• The extent to which the research will create new, sophisticated and cost effective tools for creating and assessing food health relationships likely to be of value to future users • The support of NZ researchers to be considered as having leading International reputation. • The development of NZ researchers with capabilities relevant to supporting the HVN mission including via PhD students and Postdoctoral Fellows • The development of Māori researchers with skills relevant to the HVN mission

Appendix 5 - Analysis – How applicable are HVN opportunities to product categories

Category	Gastro. Tract Functions & Confort	Building Immune Defences	Peak Nutrition for Metabolic Health	Early Life Immune Tolerance
Dairy	Prebiotic and probiotic solutions from dairy have been shown to beneficially improve transit time and/or bloating Whey proteins improve the integrity of the digestive lining Fucosylated milk oligosaccharides diminish colon motor contractions.	Prebiotic and probiotic solutions from diary have been shown to beneficially modulate gut-microbiota interactions and immune function	Evidence that higher low fat dairy improved insulin action = better glycaemic control	Fermented milk products or yogurts may have probiotic effects with potential to modulate the activity of the immune system. In addition, emerging evidence that raw milk components reduce allergy occurrence - Fortified functional yogurt recorded the fastest value growth with increasing number of products aimed at children - See PROCESSED food category for Dairy Nutritionals
Meat	Meat-derived nucleotides and nucleosides. Meat-derived phytanic acid, conjugated linoleic acids and antioxidants	Tryptophan/tyrosine metabolites have been shown to possess anti-inflammatory properties, and multiple immune cells express GPR35	Meat is a high protein foods meaning better weight managements and better glycaemic control; via enhanced insulin action	WHO recommended first weaning food as excellent source of nutrients including protein, zinc and iron Chilled or frozen beef, pig, sheep and goat meat including offal
Seafood	Seaweed (peptides, fibre) have been shown to have a positive impact on the regulation of intestinal transit. Salmon, tuna, algae (PUFAs) have been shown to beneficially improve inflammatory related GIT conditions	PUFA and multiple other factors from fish, shellfish, krill and algae have been shown to beneficially modulate immune function	Higher protein foods = better glycaemic control Also lower fat; and n-3 PUFA – positive metabolic effects Also prevention of inflammation which is key to poor metabolic health	Rich source of bioactive fatty acids, which are known modulators of inflammation and immune function Frozen fish fillets, cod, halibut, salmon
Produce	Kiwifruit (fibre, actinidin) beneficially improves transit time, bloating, frequency of bowel movement and digestive comfort. Prunes have known laxative effects. Pomegranate, Rubus berry fruit, feijoa, chestnuts	Kiwifruit, berry fruit, broccoli, avocado have been shown to have anti-inflammatory and prebiotic properties Feijoa fruit, oils and extracts purported to have immune-stimulating and anti-inflammatory activity.	Polyphenols from berry fruits etc. may prevent insulin resistance – effects on insulin secretion; possible effects on pancreatic b-cell function – new mechanisms proposed acting through prevention of human amylin aggregation in the	Rich source of antioxidants, flavonoids, with potential effects on immune and inflammatory cell function. In addition, prebiotics found naturally in many plants which can be isolated or synthesised Fresh or packaged kiwifruit, blueberries, cherries, avocados Example, Green Monkey sell pouch packaged organic baby foods

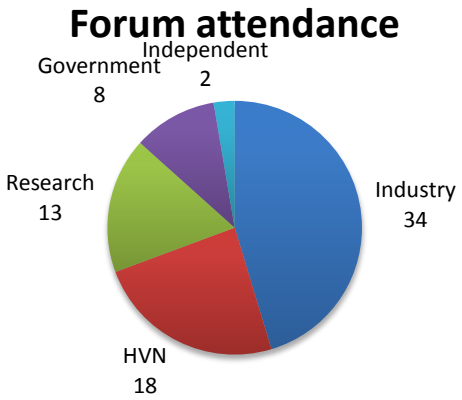
	(ellagitannins) have anti-inflammatory properties and change the gut microbiota Plant polysaccharides (fibre) are an energy source for gut microbiota (SCFAs) and have flow on anti-inflammatory and GIT integrity functions		pancreas	
Grains	 Barley grain fibre, oat grain fibre, rye fibre, wheat bran fibre are accepted ingredients for digestive health claims	 Known role of fibre (prebiotic)	 Approved health claims for diabetes = psyllium husk; established glycaemic lowering = b-glucan containing and other grains; also CVD protection from b-glucan ie cholesterol lowering e.g. oats & barley	 Wheat, maize, milled rice
Oilseeds	 Flaxseed oil etc. (fibre) has been shown to have positive effects on bowel regularity	 Grapeseed oil etc, anti-inflammatory	 Olive leaf extract = better glycaemic control	 Source of LCPUFA precursors known to modulate immune function Canola/Rape oil
Other	 NZ native plants (Koromiko, Harakeke) used in rongoā treatment for GIT complaints	 NZ native plants Fibre/prebiotic; Eggs tryptophan		
Processed	 Supplements Prebiotic, probiotic, high fibre bakery, demonstrates beneficial digestive health	 Supplements Prebiotic, probiotic, synbiotic, fish and krill oil – data demonstrates beneficial modulation of immune function	 Lower simple sugar products Better glycaemic control	 Weaning foods and food ingredients lend itself to a number of innovative formulated food opportunities which can carry a range of components and allow for product development to be undertaken in NZ including: Follow-on infant formula, Dairy nutritionals, Fortified/functional biscuits and bars Dried cereals
Beverages	 Tea for enhancing bowel movement, Anti-constipation teas, fibre drinks marketed in Asia, especially China.			

Appendix 6 - Industry feedback

Food & Beverage Exporters Forum

Nov 4th 2014, Auckland

Well attended forum - The forum was well attended with 75 participants out of the 100 RSVPs, with the following breakdown of attendees:



The following survey results are based on the 30 forms completed by industry representatives.

Moderately valuable forum - The forum was mostly rated as moderately valuable with the main complaint being the limited time for industry representatives to express their priorities and feedback on the emerging science priorities.

HVN's mission is fairly understood – The Challenge's mission was rated equally as clear and moderately clear. The lack of clarity seems to lie in the communication of HVN's scope, with some confusion on the product focus (processed foods vs. whole foods vs. dietary supplements).

NZ industry sees benefits in HVN and is willing to invest – 53% and 43% of industry representatives see HVN as very beneficial and moderately beneficial respectively for their organisations. However more tellingly 69% rate as probable a financial investment in HVN research, with on only 7% ruling it out.

Gastrointestinal and Immune Health drawing the most attention - All themes are rated equally with industry representatives rating them equally as moderately and very relevant to their organisations, and equally as moderately and very worthwhile for New Zealand to pursue. However when asked if willing to join a working group:

- 15 are willing to engage with Gastrointestinal and Immune Health theme;
- 9 with the Metabolic theme;
- 4 with the Mobility theme;
- 3 with the Maternal and Child Health theme.

Several comments point the need to include research on cognitive health targets. However several industry representatives on the contrary doubt the ability of the programme to deliver impact considering the large area covered.

Consumer insight and industry strategy should drive the science planning – The integration of consumer insight in HVN generated a lot of enthusiasm and this area is highlighted in the forms as a key tool for industry to succeed in new food-for-health product development. Several persons expressed the desire to see the prioritisation of HVN's research based on consumer insight.

However most see existing industry strategies as the legitimate driver to inform the development of HVN's research and lament the lack of consultation to date. Not only to ensure that HVN is targeting the right "new" opportunities but to ensure that the gap between those opportunities and current production capability is not too wide, as new capability and facilities are capital expensive. Several indirectly point at the rudimentary approach taken in identifying commercial opportunities, and recommend more in-depth analysis including

ROI/NPU, market access, ability of NZ industry to execute, etc. for defining the opportunities that drive HVN's focus.

Asia yes, only China no – Asia is clearly the focus of the organisations represented at the forum, however very few are ready to focus solely on China, and several point out that Europe and the US are still strong markets. Number of industry representatives point out that the geography is actually not the main preoccupation but rather the target demographics across markets.

Greater industry engagement, early on – The willingness to be closely engaged right from the beginning comes as strongly in the surveys as it did during the feedback session. The concern is that the food for health market is complicated with high barriers to market entry and that for New Zealand to be successful it needs more than just clever science, and an exhaustive and integrated support framework that spans from regulatory to commercialisation. Some organisations suggest close interactions with their marketers and product developers. This delivery-to-market oriented model and ethos needs to be at the core of HVN so it can deliver against it mission.

One-on-one services – All suggested services to come out of the network are deemed very valuable (newsletters, forums, working groups, monographs), with the following suggestions:

- Access to one-on-one tailored services;
- Access to regulatory information and advice is the most mentioned service needed. With industry seeing HVN as a conduit to assist interpret changing regulatory standards and market access standards
- Research broker model where HVN is the one stop shop for NZ industry and points to the companies to the relevant capabilities.
- Support in the identification of opportunities and commercial execution of the research, to validate claims, complete trials, etc.

HVN's suggested engagement model validated – 60% of the organisations represented at the forum see the HVN network as a valuable tool for their business, and 60% see the "no-wrong-door" model as very valuable.

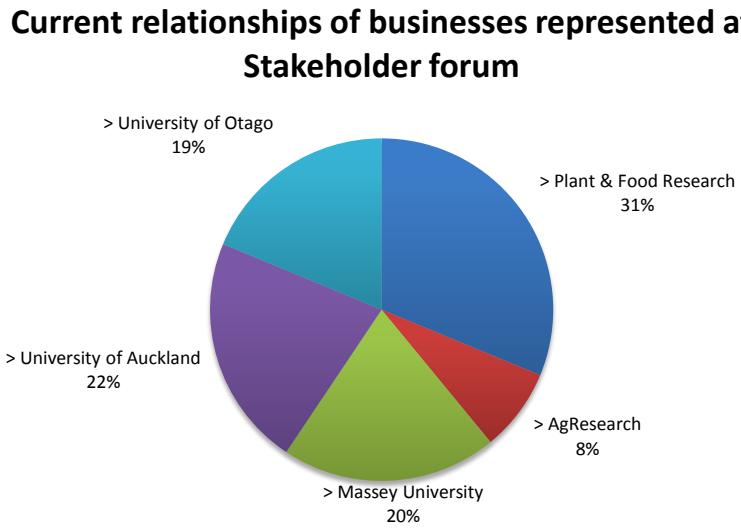
Efficient research – The expectation is that this new model of National Science Challenge will deliver best "impact for buck" thanks to its mission focus.

Working groups for industry engagement – Below are the organisations that signalled their interest in taking part in working groups. These will form the basis of our industry engagement in Q1 2015.

Themes	Organisations
Gastrointestinal and Immune Health	- Comvita - Frucor Beverages Ltd - Gibb Holdings Ltd - Go Healthy NZ - Goodman Fielder - Manuka Health - Manuka Honey - NZ Blackcurrant Cooperative - NZ Extracts Ltd - Phytomed - Seperex Nutritionals - Synlait Milk Ltd - Zenoch Management - Zespri
Metabolic	- Airborne Honey - Apollo Foods - Comvita - Frucor Beverages Ltd - Gibb Holdings Ltd - Goodman Fielder - Manuka Health - NZ Extracts Ltd - Zenoch Management - Zespri

Mobility	- Blackcurrants NZ Inc. - Comvita - Fonterra - Gibb Holding LTD - Gibb Holdings Ltd - Manuka Health - Powerhouse - Seperex Nutritionals - Zenoch Management
Maternal and Child Health	- Airborne Honey - Dairy Goat Cooperative - Douglas Nutrition - Fonterra - Manuka Health - Powerhouse - Seperex Nutritionals - Synlait Milk Ltd - Zenoch Management

Great industry engagement through Plant & Food Research – the graph below indicates what relationships the businesses present at the forum have.



Appendix 7 – Consumer-led opportunities identified by High-Value Nutrition.

Health targets	Opportunities identified	Description
Metabolic Health	#1 - "Lean for Life"	Maintaining a Healthy Weight and Preventing Obesity
	# 2 - "Peak Nutrition for Metabolic Health"	Maintaining Metabolic Health and Preventing Diabetes
	# 3 - "Lean for Life"	Preventing Obesity the role of the gut microbiome in the regulation of satiety, food intake and weight management
	# 4 - "Peak Nutrition for Metabolic Health"	Preventing Diabetes lipid overspill and ectopic lipid storage in organs such a liver as a driver of dysglycaemia and other metabolic complications
	# 5 - "Peak Nutrition for Metabolic Health"	Preventing Diabetes the role of the gut microbiome in the regulation of blood glucose and insulin secretion/sensitivity
	# 6 - "Peak Nutrition for Metabolic Health":	Preventing Diabetes-associated Loss of Cognition in older adults targeting Alzheimer's disease 'diabetes of the brain' and dementias of similar aetiology
Maternal & Child Health	# 1 - Early Life Start towards Leaness	Optimal Growth to the meet the needs of consumers seeking to optimize the development of their child with regards to leaness and linear growth.
	# 2 - Early Life Immune Tolerance	To develop foods that optimise the development of their child with an immune profile that lowers allergy risk.
	# 3 - Early Life Brain Resilience	To develop foods that optimises brain development to influence brain resilience.
Mobility	#1 - Improved Mobility (through improving Movement-related Discomfort, Flexibility, and Recovery [MDFR])	Undertake investigations on improving biomarkers of movement-related discomfort, flexibility and recovery (MDFR) through nutrition interventions.
	#2 - Supporting Physical Capacity through Superior and Defined Phytochemical-based Foods.	Developing the science to create phytochemical-based foods with superior efficacy to support improved physical capacity and performance for the ageing consumer.
	#3 - Superior muscle performance/recovery/adaptation from functional synergies between fruit phytochemicals and dairy (whey) proteins.	To scientific validate the synergistic efficacy of key phytochemical and whey protein-based food products to assist mobility and the ability to recover from exercise, assist in enhancing the benefits of regular exercise for a healthy and functional musculoskeletal system and physical wellbeing.
	# 4 - Reactive oxygen species and rest homes	Examine the oxidative responses to fruit and vegetable phytochemicals, to determine if they have a similar effect as exercise on attenuated the age-related decline in muscle nervous control.
Gut & Immune Health	#1 - Elite GUT – Improvement of GIT Function and Comfort	To understand the link between GIT health, comfort and wellbeing with the aim of developing F&B products that support work and play performance excellence for the 'Worried Well'.
	#2 - Elite GUT – Improving GIT Defences	To support GIT defences, specifically to mitigate antibiotic and/or stress driven GIT dysbiosis observed during colds/flu infections.
	# 3 - Elite GUT – Facilitating Digestion	To identify how to prevent nutrition related diseases and improve physical and mental well-being through optimal digestion and absorption of nutrients.
	# 4 - Elite IMMUNITY - Immune Support for Allergy Management	For F&B products designed to mitigate allergic responses, through beneficial modulation of GIT microbiota-immune interactions.
	# 5 - Elite IMMUNITY - Enhanced Respiratory Health for Modern Urban Living	To develop high-value validated products that could deliver benefits encompassing managing inflammation at the airways, improving lung function and oxygen delivery and circulation and improving recovery from exposure to pollution.

Appendix 8. MBIE Research Contracts "Mapped" to HVN and CRI Core Funding Aligned to HVN

MBIE RESEARCH CONTRACTS "MAPPED" TO HVN

C10X1003 - Dairy-based food solutions for improved intestinal barrier function for infants and the aged ($1,332,174 per annum, end date 2016).

The research aims to test the hypothesis that dairy-based ingredients promote the development and maintenance of a resilient intestinal barrier to improve health and well-being. It involves AgResearch and Massey University personnel. This programme receives direct cash and in-kind co-funding from Fonterra. Key activities include a translational approach that includes *in vitro* and *in vivo* measurement of intestinal permeability and motility (screening and mechanisms of action) to support the health benefits of dairy-based ingredients for intestinal function and comfort. Cell-based and animal models have been established and candidate ingredients identified for mechanistic studies (on-going). Unique systems that will enable the determination of the mechanisms of action of the obligate anaerobic bacteria have been validated. A novel technology to deliver these bacterial strains in a viable and shelf-stable powder based format was also developed. This programme is supported by collaborations with Flinders University, McMaster University and Wageningen University.

MAUX1309 - Biomarker Development and Validation for use in Human Clinical Studies of Food in Asian Populations.

Partnership between Massey University, AgResearch and University of Auckland (Total value of the contract $375,000 per annum; Subcontract to AgResearch $125,000 per annum, end date 2016) and A*STAR Institutes (Singapore Institute of Clinical Sciences; Clinical Imaging Research Centre; Institute of Materials Research and Engineering). The project aims to identify biomarkers using imaging and metabolic methods (metabolomics) for improving our understanding of the diabetes risk in SC women and to use these biomarkers for determining the effects of dietary food strategies on the diabetes risk. Within Singapore, this project will continue the development of excellence in high-throughput and state-of-the-art medical technologies, yet importantly will be linked to with the emerging area of research in Foods for Health for Singapore.

C10X1317- Encapsulation technology for delivering food bioactives to the surface of the small intestine.

($125,000 per annum, end date 2016) The objective of this joint NZ – Singapore project is to develop and demonstrate performance of an encapsulation technology which enables a functional food ingredient to be delivered in an active form to a specific part of the gastrointestinal tract.

C11X1304 – **Foods for health: Biomarkers from existing data** ($575k pa, end date 2014). This research creates a searchable database of biomarkers that the NZ food industry can use to substantiate the development of a health claim for food products and case studies of food health claim applications that can be used to inform industry about the process of using biomarkers to substantiate health claims for foods. It involves PFR, AgR and UoA researchers.

C11X1003 - **Fruit foods for inappropriate inflammation** ($664k pa, end date 2015). Research to determine whether fruit compounds can provide 'natural' and safer alternatives for inflammation control, through their actions at multiple stages of inflammation. The team combines PFR fruit science and biomedical expertise with the inflammation and human clinical trial expertise of scientists at the Malaghan Institute of Medical Research and the NZ Medical Research Institute. Airway inflammation is the model system of choice. Numerous cell based assays, animal and human airway inflammation capability established and validated, lead fruit compounds screened and identified with mechanism of biological action and bioactive identification insights. Synergistic activities between fruits are being revealed. Lead fruit compounds progressed through acute and chronic animal models of airway inflammation.

C11X1004 – **Lifestyle food for appetite control** ($3.27M pa, end date 2016). Discovering how plant foods suppress appetite and food intake by developing an in-depth understanding of novel appetite control mechanisms, discovering natural ingredients that can be used for appetite control, and creating fresh and processed prototype foods that deliver appetite control to consumers. It involves researchers from PFR, UoA and Massey.

C11X1312 – **Foods for health at different life-stages** ($2.3M pa, end date 2017). The programme will investigate digestion and fermentation of plant-based foods and their functionality in the gut i.e. on gut transit, release and uptake of small molecules, laxation, prebiotic activity and mucosal immunity. It involves PFR, AgR, Callaghan Innovation, Massey, UoA, and UoO personnel.

CRI CORE FUNDING ALIGNED TO HVN

AgRese4arch - Aligned CRI Core

Research being undertaken via AgResearch core funding has also been aligned. A total of $4.609M of AgResearch's core funding is currently aligned to HVN. The science includes capability from all four HVN themes (Table 1).

Table 1. AgResearch Core projects aligned to HVN in 2014/15.

Project	Clinical Application	Biomarkers	Consumer Preferences	Science of Food	Total (FY15)
1. HVN-Core Programme					
Nutritional Strategies for an Ageing Population	$200,000	$100,000			$300,000
Gut-brain axis		$763,000			$763,000
Biomarkers for nutrition and health		$350,000			$350,000
Postdoctoral Fellowships		$170,000			$170,000
Tracking the Nutritional Value of Food through Processing				$300,000	$300,000
2. Added-Value Foods Programme					
Digestion Modelling				$200,000	$200,000
NZ Specific Products			$60,000	$60,000	$120,000
Naturally Dairy	$100,000			$101,000	$201,000
Structure & Delivery				$251,000	$251,000
3. Other projects					
Value from Quality			$350,000	$450,000	$800,000*
Red Meat Combifoods				$1,154.000	$1,154.000
Sub Total	**$300,000**	**$1,383,000**	**$410,000**	**$2,516,000**	
Grand Total					**$4,609,000**

** Not all research in this programme is directly aligned to the Challenge. Total programme funding is $1,262,000.*

Please Note: CRI core funding aligned to HVN is subject to AgResearch Board approval. The projects identified here are valid for 2014/15 only as core science investments are reviewed annually.

Nutritional Strategies for an Ageing Population: The "greying" of society is a demographic reality that will impact the food market worldwide. The loss of muscle mass and function with ageing has a major detrimental impact on human wellbeing, functioning, morbidity and mortality. This project is investigating whether protein-rich food solutions, particularly those derived from dairy or meat products, influence the key mechanisms which regulate the loss of muscle mass associated with ageing, and thus help to mitigate this muscle loss. The key techniques developed using tissues from an animal model of frailty (markers of muscle inflammation, oxidative stress, and metabolic dysfunction; molecular determinants of muscle mass and

composition; muscle and plasma miRNA profiles as they related to muscle mass and composition), and data from these studies, have informed the design of human clinical intervention studies which are on-going. This is a collaboration with the University of Auckland.

Gut-brain axis (GBA): Bi-directional communication between the gastrointestinal tract (GIT) and the brain, referred to as the GBA, is increasingly recognised as critical to the impact of food on brain health. Diet has been extensively shown to affect the composition of the GIT microbiota and its metabolism, thus specific foods or diets could be used to manipulate the GIT microbiota to support brain health. This project is developing and validating models of the GBA in order to investigate the mechanisms by which dairy (complex lipids, probiotics) and meat ingredients may have beneficial effects via a flow-on effects from the GIT to the brain (GBA). This is a collaboration with the Alimentary Pharmabiotic Centre and Flinders University.

Biomarkers for nutrition and health: Short and long-term breast feeding are thought to have health benefits for the infant. However, the impacts of factors such as breast feeding patterns and maternal diet on breast milk composition, and thus its potential effects on infant nutrition and health, is not well understood. This project will generate compositional information at the metabolite level, which could be related to infant health and potentially important in the infant formula industry. Knowledge outcomes include; methods for preparing samples, data on sensitivity and reproducibility of methods, with the ideal outcome being the detection of key biomarkers related to health status and/or maternal diet. This will provide knowledge that will contribute to the development of New Zealand functional foods with validated effects on infant health. This is a collaboration with the University of Auckland and Turku University.

Postdoctoral Fellowships: Two Postdoctoral Fellows will investigate the effects of food ingredients on intestinal function using novel techniques. The first Fellow, based at AgResearch, is developing a primary piglet epithelial cell model to validate the efficacy of food ingredients short-listed during screening for GIT barrier integrity benefits using an epithelial cell line. The second Fellow, based at Wageningen University (the Netherlands), is determining whether food ingredients can affect the function of intraepithelial lymphocytes by activating aryl hydrocarbon receptor signalling, and thus affects mucosal tolerance and immunity in humans.

Tracking the Nutritional Value of Food through Processing: There is increasing evidence that the nutritional value of food can be impacted by bimolecular chemical changes during processing. For example, protein modifications and chemical changes to lipids occur during pasteurisation of milk or cooking. This project will develop tools which enable end-users to monitor molecular changes in food components associated with nutritional value, and will provide expertise which enables this data to be used effectively.

Digestion Modelling: Digestion is a key physiological process which dictates the availability of food components in the GIT and their subsequent absorption by the body. This project will develop tools which enable digestion to be modelled and tracked at a molecular level. This will provide us with the ability to design foods which are digested in a controlled manner, leading to differentiated products with superior nutritional qualities.

NZ Specific Products: One of the major issues facing New Zealand exporters is the fact that although our products are differentiated in the market by virtue of their association to New Zealand, there is a lack of evidence to substantiate claims that NZ products are intrinsically different or more valuable than our competitor's. This objective will undertake studies which provide this evidence.

Naturally Dairy: Milk is an excellent source of nutrition but also provides other activities which support health. There is an accumulation of scientific evidence which indicates that many of these benefits are lost when milk is highly processed. We hypothesise that the use of 'softer' or alternate processing can create milk products which retain the natural benefits of milk, while meeting food safety and product formulation requirements. This project will undertake studies which assess the health supporting properties of these alternatively processed milks.

Food Structure and Delivery: Food structure has a large influence on the nutritional, functional and sensory properties of foods. This objective will investigate the role of food structure in controlling desirable characteristics of dairy and meat products, including the delivery of high value components, then determine how these structures can be modified through processing and food manufacturing.

Value from Quality: Value From Quality covers a range of objectives aimed at increasing the productivity and profitability for the NZ sheep and beef industry. Specific goals are maximising the shelf life and quality from chilled lamb, maximising the quality and value from red meat, production and export of safer meat products, and novel technologies for halal stunning and slaughter.

Red Meat Combifoods: Proteins in red meat are a rich resource that can be captured for wider application in foods beyond traditional dishes. The Combifoods project is a platform for technologies and industry engagement to support the creation and export of high-value, meat-based ingredients for food manufacturers

that highlight optimised nutritional composition, desirable organoleptics, and physiological and processing benefits.

Plant and Food Research - Aligned CRI Core

A total of $1.9M of PFR's core funding has been aligned to HVN. The science includes capability from all four HVN themes (Table 1) and aligns with the four priorities target areas identified by the HVN Science Leadership Team (Table 2).

The majority of PFR's aligned core science is driven by industry partners who have a strategic export focus (Table 1). The remainder is discovery science; investigative research that has the potential to add value to horticulture, arable and seafood sectors and multiple food and beverage businesses.

Table 1. PFR Core projects aligned to HVN in 2014/15. Projects with an asterisk have strong industry partner relationships with an export focus.

Project Name/Number/ Science Leader	Clinical Application	Biomarkers	Consumer Preferences	Science of Food	Sector alignment
#1921-Consumer & Health		$ 150,000	$ 200,000		Food & Beverage*
#1458-Benefits beyond eating			$ 125,000		Food & Beverage*
#1170-Foods for endurance sports through enhanced bio-energetic efficiency	$ 300,000	$ 125,000			Horticulture*
#1205-Wheats for wellness				$ 150,000	Arable (cereal)*
#1245-Food Innovation Potato Science			$ 100,000	$ 100,000	Potato*
#1477- miRNA and Health	$ 50,000	$ 150,000		$ 150,000	Discovery Science
#1480-Resetting clock genes in the gut	$ 150,000	$ 150,000			Discovery Science
Sub Total	**$ 500,000**	**$ 575,000**	**$ 425,000**	**$ 400,000**	
Grand Total					**$ 1,900,000**

Table 2. Alignment of PFR Core science with HVN priority targets. Future direction indicated with (+).

Project Number & Name	Mobility	Gut / Immune Health	Maternal / Child Health	Metabolic Disease
#1921-Consumer & Health	+	+	+	+
#1458-Benefits beyond eating	+	+	+	+
#1170-Foods for endurance sports through enhanced bio-energetic efficiency	+++			+
#1205-Wheats for wellness		+++		(+)
#1245-Food Innovation Potato Science		++		++
#1477- miRNA and Health		++		++
#1480-Resetting clock genes in the gut		++		

CRI core funding aligned to HVN is subject to PFR Board approval. The projects identified here are valid for 2014/15 only as core science investments are reviewed annually. The current Core projects aligned with HVN include:

#1921 – **Consumer & Health.** PFR partners with MoH to deliver the NZ Food Composition Database to the F&B Industry. PFR is investing Core funding in expanding the database to allow automatic calculation for nutrient content claim purposes and capture preapproved general level nutrition and health claims to provide enhanced functionality for New Zealand food industry and other users. Also includes a marketing component aimed at conducting consumer insights research in China and linking outcomes with texture preference.

#1458 – **Benefits Beyond Eating.** An underpinning research project which explores consumer behaviour to understand what makes a meal meaningful and memorable to derive strategies for improved food product and service experiences.

#1170 – **Foods for Endurance Sports through Enhanced Bio-Energetic Efficiency.** This project aims to identify phytochemicals that facilitate mitochondrial bio-efficiency (mitochondrial complex efficiency and mitochondrial number) to assist human cognitive performance (ability to plan/read/predict game play), mood/motivation (drive, stamina), and physical prowess (endurance, strength, speed, agility) that will combine to maximize overall sporting performance and sporting achievement. The ultimate goal is to underpin a suite of novel functional sports products for intelligent physical performance with a scientifically validated point of difference in the market place.

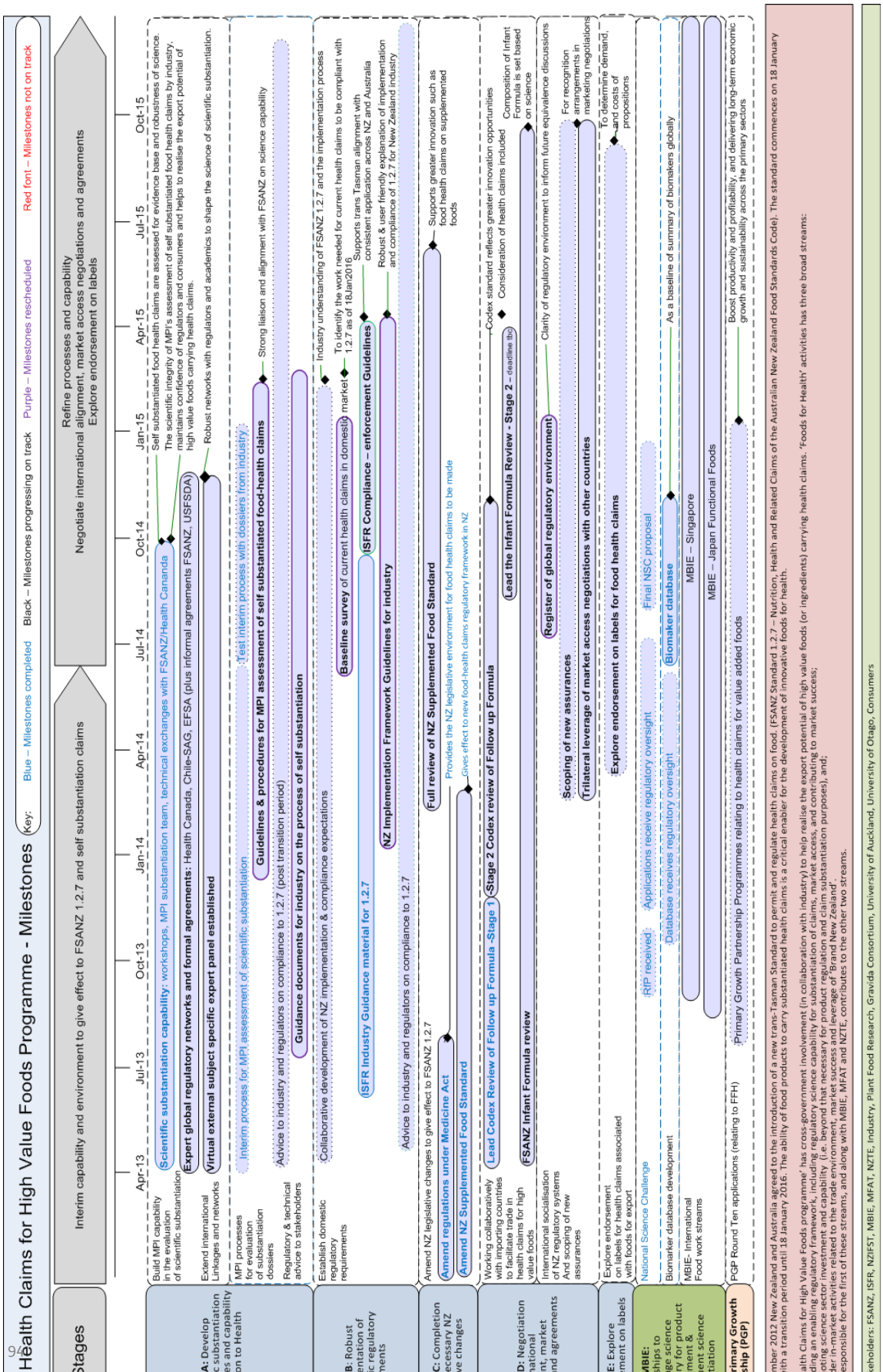
#1205 – **Wheats for Wellness.** The programme's main objective is to research and develop breeding and processing mitigation strategies that will lead to a reduction in the gluten-intolerance epitope concentrations in the proteins of NZ wheat cultivars and food products made from them. A second objective is to explore FODMAPS (fermentable oligo-, di, mono-saccharides and polyols) in PFR wheats and arable crops. The inability to absorb FODMAPS in some individuals produces GIT disorders that are often confused with gluten intolerance. To achieve both goals we are developing sophisticated LC-MS and HPLC based screening systems for quantifying the key peptide epitopes and carbohydrates that are the cause of these clinical conditions. These screens will then be used to measure and refine the efficacy of mitigation strategies.

#1245 – **Food Innovation Potato Science.** This project's primary goal is to support and grow the New Zealand potato industry by identifying novel end-uses for potatoes including the production of potato-based convenience foods with enhanced nutritional quality. One objective includes a GIT health research component to quantify the nutritional and textural attributes of potato ingredients/foods and investigate starch digestibility. The programme is also investigating potato flavours and consumer preferences.

#1477 – **miRNA and Health.** This project investigates the bioavailability and ability of dietary plant microRNAs to modulate human gene expression to benefit health and wellbeing in a pilot human clinical feeding study. The aim is to identify specific plant dietary sources with the potential for cross kingdom regulation of human genes to offer NZ agribusiness a novel mechanistic framework for identifying a new generation of health claims associated with the long-term regular consumption of specific whole fruit and vegetables.

#1480 – **Resetting Clock Genes in the Gut.** The project investigates the link between the host microbiome and GIT clock genes in models of circadian disruption to test the hypothesis that GIT microbiota and their metabolites modulate circadian controlled functions such as nutrient uptake and metabolism. The aim is to provide new diet based strategies to correct circadian disruption and the metabolic pathologies that result.

Appendix 9 – MPI Health Claims for High-Value Foods Programme



Appendix 10 - Intellectual Property Management Plan

IP Management Plan for the High-Value Nutrition National Science Challenge

1.1 This plan is subject to any relevant provisions of the Contract, must be read in accordance with the provisions of it, and may not be inconsistent with it.

1.2 Project IP will be owned by the Party or Parties that creates it (and according to any internal policies for its assignment), who will be responsible for decisions concerning protection, management and commercialisation of the Intellectual Property that arises.

1.3 Where Project IP is created by more than one of the Parties, the Parties who created it shall agree which of them shall be the Managing Party. The Managing Party will be responsible for decisions concerning protection, management and commercialisation of the Project IP. Generally, for the purposes of guidance, the Managing Party will be the Party which is best placed to create value from the Project IP and/or with any other parties involved in the project consistent with the mission and objectives. Benefits will be shared between the creating Parties in shares reflecting the relative input to the Project IP, including Background IP and know how provided, inventorship and costs of commercialisation and after recognising the relative risks of the different Parties (this may include the additional financial risks of the Managing Party). In practice the parties are encouraged to form a joint management committee of all parties involved in any commercial project involving Project IP to facilitate the making of timely decisions during its protection and commercialisation.

1.4 Parties will report all Project IP to the Director via the Commercialisation Facilitator, who will keep a register of reported IP to support reporting to the Ministry.

1.5 It is acknowledged that where Project IP is developed in collaboration with co-funders / industry partners / businesses the regime set out in clauses 1.2 and 1.3 may not apply and it is expected that the Parties involved will enter into appropriate agreements with the co-funders / industry partners /businesses to:
(a) ensure Project IP is developed in a manner that will advance the purposes of the Challenge. This may involve limiting a third party or businesses license to use Project IP to a particular market segment(s), on an exclusive or non-exclusive basis ; and

(b) agree commercialisation and revenue sharing arrangements.

1.6 Subject to confidentiality provisions defined in clause 23 of the Collaboration Agreement, Project IP will be licensed non-exclusively and royalty free to all Parties for the purposes of Research and/or Related activities as well as educational activities.

1.7 The underlying purpose of the Challenge is to create Benefit for New Zealand. Each Party will observe the IP Policies and Principles set out in Appendix 4 to the Collaboration Agreement when making decisions about the management of any Project IP.

1.8 Before Project IP (including any created jointly with third parties) is commercialised the owning/managing party or parties must present a commercialisation plan to HVN for review. The Commercialisation Facilitator shall review any such plans for alignment with the vision/mission and contract objectives of HVN. If he or she has any concerns that the plan is not consistent with the contract including this IP Management Plan and the IP principles below then he may seek changes to the plan. If the revised plan is not satisfactory the matter will be escalated to the Director and Chair of the HVN Board who will liaise with the parties to resolve any issues or concerns and ensure the use of IP is consistent with this plan and the IP principles.

1.9 Progress on commercialisation or translation or implementation plans shall be reported annually to the Commercialisation Facilitator, who will further report to the Director, SLT and the HVN Board, for the purposes of reporting outcomes to the Ministry. Such reporting shall be subject to ensuring protection of commercially sensitive or confidential information.
1.10 Post contract reporting to the Ministry by the Challenge Contractor may be required to allow the Ministry to review or evaluate the delivery of the outcomes of the Challenge. The Parties shall maintain, and provide to the Challenge Contractor on reasonable notice, sufficient information and reports to allow the Ministry to review the delivery of outcomes by the Challenge for a period of at least 7 years after the end of the Challenge, or such other period specified in any Subcontracts or the Contract.

1.11 Nothing in this plan shall change the ownership of any Background IP. Parties will grant a non-exclusive, royalty-free, non-transferable licence of relevant Background IP to each other, to the extent that they are able, unless there are reasonable grounds not to grant such a licence. Such licence shall be solely for the purposes of the Research and/or Related Activities. Any commercial use of Background IP shall require the grant of a separate licence which shall be negotiated between the interested Parties.

1.12 Background IP made available by third parties including privately owned businesses, including enhancements to it made during the programme, will be owned by the third party or business that provides it. The owner of any Background IP can continue to use that IP for any purpose. Any such third parties will be asked to grant a license of relevant Background IP to relevant Parties to the extent that they are able and that access to the Background IP is needed to carry out their project.

1.13 In some cases, the best value to New Zealand may be through the dissemination of research results to participating stakeholders (e.g. the HVN Food and Beverage Exporters Network or FBEN). In this case the Project IP may be (by mutual agreement with the Director):

- Made available to participating stakeholders in FBEN on a first look basis and be available for license on normal commercial terms, or
- Made available to selected co-investing third parties on a first right of use within a defined parameters basis, or
- Publically disseminated

1.14 References in this plan to the Collaboration Agreement are to the binding Collaboration Agreement between the HVN Challenge Members dated on or about the same date as this Challenge Programme Agreement. Capitalised terms used in this plan have the same meaning as in the Collaboration Agreement.

Appendix 11 – NSCs common indicators

National Science Challenges: Common Indicators

Activity area	Dimensions (what we want to see happening)	What we will measure
1. Delivery of Challenge objective	**To what extent do all Challenge activities focus on and contribute to achieving the Challenge objective?** 1.1. Challenge objective informs governance, management, and research decisions 1.2. Challenge consortium has a clear pathway to achieve the Challenge objective and makes significant progress along the pathway 1.3. Challenge portfolio delivers outputs that contribute to the Challenge objective	Annual report on research, business plans Challenge-specific indicators
All of the below is assessed within the context of achieving the Challenge objective:		
2. Effective governance and management	**To what extent do the right governance and management arrangements exist and work effectively?** 2.1. Governance entity operates effectively and makes informed, timely decisions in line with Challenge objective: • resource allocation decisions generate impact and value for money • science quality is ensured, fit for purpose, and constantly improved • Challenge performance and risks are managed • governance group performance is regularly assessed, membership is reviewed as necessary 2.2. Adequate and effective processes are in place and used in areas such as performance reporting and monitoring, financial management, audit • plans are dynamic and adjusted for changes in the external environment	Annual report on research, business plans Value for money of governance and management activities (and cost vs budget) Governance entity performance Evidence of quality processes (reporting, financial management etc) Performance issues (if any) are addressed
3. Best team collaboration	**To what extent is New Zealand's best team working on delivering the Challenge objectives?** 3.1. Challenge team works together across disciplines and member institutions (relationships are built that did not exist previously) and draws on and aligns capabilities and resources outside Challenge 3.2. Challenge team has the right capability, gaps are filled, and Challenge tests itself with new ideas, approaches, and mechanisms 3.3. Emerging talent has opportunities (in research or leadership roles) 3.4. International science expertise is used where appropriate	Annual report on research, business plans Connections across teams, disciplines, organisations In-flow of new researchers Building of skills, expertise, capability of team members Relationships with international researchers
4. Stakeholder collaboration	**To what extent is the Challenge engaging with stakeholders and to what extent are stakeholders using the Challenge research results?** 4.1. Stakeholders inform and influence Challenge priorities and research agenda, and take up and use research results 4.2. Challenge influences investments of external stakeholders	Annual report on research, business plans External fee-for-service revenue earned Value of co-funding, in-kind, other support Engagement/relationships with stakeholders Commercialisation outputs, eg patents, licences, spin-outs, new products, services and processes Stakeholder adoption and use of Challenge-generated knowledge and technology
5. Māori involvement and mātauranga	**To what extent are Māori and mātauranga Māori engaged to achieve the Challenge objective? To what extent is the Challenge addressing the needs and aspirations of Māori?** 5.1. Māori are involved in the Challenge or at least add influence - where appropriate - as researchers, stakeholders, governance entity members, advisors 5.2. Challenge research unlocks knowledge, resources, and potential of Māori 5.3. Mātauranga Māori is used in the Challenge research, where appropriate	Annual report on research, business plans New products, services, processes developed based on mātauranga Māori Engagements, collaborations, partnerships, relationships built with Māori (individuals, businesses, incorporations, rūnanga, trusts, iwi, hapū, marae)
6. Public participation in the science process	**To what extent is there engagement between the Challenge and the public?** 6.1. Challenge is relevant to New Zealanders; members of the public are involved in the Challenge where appropriate, and engaged in the aspirations of the Challenge.	Annual report on research, business plans Public engagement activities, eg seminars, website hits, school visits, sponsorships, publications in popular press, TV and radio programmes etc Change in public attitudes towards science