MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Summary of Discussions

New Zealand–Singapore Joint Future Foods Workshop

4-5 November 2019

A*STAR, Singapore

Workshop context

The 2-day Future Foods workshop was intended to scope out potential priority areas of research and strategic interest to both New Zealand and Singapore, to inform the design of a joint coherent sustainable programme of holistic end-to-end projects in future foods. It was attended by participants from both New Zealand and Singapore, consisting of over 40 scientists (see Appendix for names and emails) and representing a large range of universities, research institutes, and independent entities, as well as invited industry representatives from Wilmar International and Wakatū Incorporation.

The workshop opened with presentations from Wilmar International and Wakatū Incorporation, to illustrate the context in which industry R&D is currently working. These examples presented by industry gave a useful setting of potential future directions, without detracting from the fact that the core of the proposed three-year partnership between Singapore and New Zealand is anticipated to fall at the pre-commercial end of research.

Each scientist gave a three-minute presentation on their expertise and the current state of research within each of their respective teams and institutions across New Zealand and Singapore. The rest of the workshop then followed a pattern of small-group sessions focussed around theme exploration and specific questions or 'challenges', in a bid to draw out a variety of suggestions and first-step propositions for potential research partnerships. We worked on a previously agreed underlying structure that the programme as a whole would need to draw on unique ingredients, approaches, and themes across consumer, materials, processing/engineering, and metabolic health implications.

This summary report captures the following:

- Outcomes
- Project ideas for Materials, Processes, Health, and Consumer
- Discussions between scientists on forming partnerships
    - What expertise do we have at the workshop?
    - What expertise is missing at the workshop?
    - How to allow cross-fertilisation of ideas?
    - Have we missed any key opportunities?

- Ideation: Advancing programme goals
    - How do we create a coherent programme?
    - How do we ensure a balanced representation of scientists?
    - How do we ensure sustainability of the research relationships?
    - How do we ensure engagement with industry?

Outcomes

The various discussions at the workshop identified a range of potential areas for joint research, aiming to cover the potential for collaborative projects not only amongst attending participants, but also between their respective broader research communities not necessarily present at the workshop.

The following notes capture the various discussions as they took place, in as full a manner as possible, and have not been edited. They should serve as guidance for proposals into the Call for Proposals, and illustrate where we are specifically aware of feasible joint projects.

However, we remain open to proposals in areas not covered in the following, provided they are indeed submitted as a joint proposal with a balanced spread of expertise and commitment (financial or in-kind) from both countries.

Project ideas

During the first theme exploration, the participants were divided into 4 groups: Materials, Processes, Health, and Consumer; and asked to identify and prioritise up to 3 top cross-cutting/multidisciplinary research topics based on alignment with existing New Zealand and Singapore research capabilities and national priorities.

Materials

- Leveraging indigenous proteins *
    - Screening (health & safety, materials, processing, consumer)
    - Production/extraction
- Interactions of novel plant proteins
    - Other plant protein, animal protein, other macromolecules, animal cells
    - Materials – physico-chemical properties
    - Processes – mod. Interactions
    - Health & Safety – nutritional and anti-nutritional qualities, bioactive peptides, digestibility
    - Consumer – acceptance of blends, labelling, and regulation
- Upcycling of biowaste using microbial fermentation
    - Input (low cost, possibly low quality) → Process (can be expensive) → Output (food, high value bioactives)
    - Potential issues (transportation, shelf life, power/water)

Processes

- Big Questions:
    - Promote alternative protein consumption – health, cost, environment, food security, diversification (within plant protein) → increase economy
    - What food formats?
    - Upstream and downstream processing
    - Research gap in both developing ingredients from plant-based materials with functionality for processing and in processing those ingredients in food applications (feedstock → ingredient → final product)
    - 'Functionality' needs to be well defined: for example when extracting proteins from plants they have functionality in the plant (e.g. storage protein), when used in food manufacturing they have functionality for processing (eg emulsification), and when consumed they have functionality for health (eg amino acid profile).
- Sourcing (novel ingredients – hemp/microbial/seaweed/fungal/cereals/etc., combinations and interactions, mimics, nutrition, what NZ can offer, what SG people prefer, properties impacted by processing)
    - Meat analogs or new?
    - Blending plant and animals/others?
    - Why eat them (health, environment, animal welfare, cost, taste, different target groups – elderly/religion)?
- Upstream processing (max. yield, co-extracted materials, desired functionality) *
    - Seaweed (energy), enzyme hydrolysis, electrospray, fractionation & characterization, waste valorization, blend proteins, microbial protein, micro algae
    - Effect of processing on proteins
- Downstream processing (optimising functionality, product, good policy, health outcomes) *
    - Food structure, 3D printing, texturizing, blend proteins, electrospray, meat analog, after extrusion, protein-polysaccharide interactions (fungal, structure/texture, digestion, gut microbial)
    - Optimisation of food concepts based on consumer perception and government (e.g. meet policy requirements)
    - Improve functionality for consumer

Health

- Leveraging the advantages of the whole food protein matrix
    - Compare novel plant-proteins → impact upon functionality (specific nutrient/health targets) → impact upon metabolic health (CVD, T2DM) and consequences of aging (quality of life, mobility, anti-inflammation)
    - Impact of minimal processing (whole food protein matrix) on protein quality/adaptation, in vitro digestibility (health effects – lean muscle mass, FBG/insulin sensitivity), and enhanced nutrient delivery (bioaccessibility and bioavailability)
    - Interactions between food components on a molecular scale and the impact upon digestion, satiety, and nutrient delivery/bioavailability
- Effect of protein components on microbiome
    - Benefits of plant proteins on health (digestibility, microbiome, systemic effects)
    - Local gastro-intestinal effects (in vitro, human clinical, and animal model systems)
    - The extent of processing of whole protein plant-based food and the impact upon the gut microbiome
    - Impact of passive and active food molecular passenger components on the gut microbiome under digestive conditions
- Consumer profiles and drivers
    - What do Asian versus Western consumers need/want?
    - What do people mean by 'minimal processing'?
    - What are the drivers to purchase/eat (is health a motivating factor, satiety/appetite regulation) and how to change?
    - What type of protein (what are we seeking to replace, what do we add to plant protein – nutrient density), taste, health benefits?
    - Ageing with enhanced mobility and anti-inflammation as consumer drivers for future food purchases
    - Combination of plant proteins with traditional food to leverage the advantages (textural, taste, and nutritional) in new food products

Consumer

- Consumer insights and engagement *
    - Understand gap between what consumers say they want and what they choose
    - Consumer preference (sensory properties? materials? processing methods? health?), but we don't know the drivers
    - Effect of marketing (triggers for continued behaviour) and language used (eg. meat analogue)
    - Not all consumers are the same – need for understanding segmentation in new protein space (cultural, physiological, other? basis, need to use new ways of assessing behaviour)

- Understanding the acceptable sensory space is key as it known to be a barrier *
    - Type/source of protein (e.g. insects = yum/yuck)
    - New protein foods category, as opposed to just meat analogues or meat-like products
    - Understand relative trade-offs/interactions between sensory, health, and other key drivers

During the second theme exploration, the participants were once again divided into different groups, based on the top 4 most voted research topics (see * above, in some cases merged together), and asked to discuss potential research areas which capitalised on existing or new areas of research strengths in both New Zealand and Singapore.

1. Leveraging indigenous proteins

- Why indigenous?
    - Unique mixture
    - Diversity
    - Indigenous knowledge
- Capabilities needed
    - Cultural/Consumer insights
    - Mātauranga Māori (including appropriate protection, access, and benefit sharing)
    - Health (metabolomics, non-toxic, cytotoxicity, allergenicity, gut health, anti-inflammatory, amino acids/nutrition, anti-oxidant, non-animal models, colonic fermentation, digestibility)
    - Physico-chemical (unique components, utility, proteome)
    - Whole-organism analysis

2. Upstream and downstream processing

- Upstream
    - Source type/properties (terrestrial, marine, microbial)
    - Isolation/concentration of crude/fraction protein (total utilisation – side streams)
    - Extraction (screening tech, novel methods)
    - Optimisation (yield, function, cost, scalability, commercialisation)
    - Characterisation (proteomics, peptidomics, amino acid profile, rheology, emulsification, gelation, anti/alt nutrients)
- Downstream
    - Extraction (pH, T, ionic strength, shear, blending, modelling, fermentation, enzyme)
    - Protein structure and function (molecular/microstructure, macrostructure, solubility, digestibility, bioactivity, sensory)
    - B to B (semi-finished)
    - B to C (food safety, allergenicity, composition of macro/micro nutrients)

3. *Effect of proteins on microbiome*

- H1: The extent of processing of whole protein plant-based food and impacts upon the gut microbiome composition and microbiome-derived metabolites
    - Minimally vs extensively processed
    - Digestibility as a function of processing
    - What protein sources should be studied? Novel and traditional sources of proteins
    - Capabilities needed:
        - Metagenomics
        - Metabolomics
        - Proteomics/digestion
        - In vitro gastrointestinal simulators
- H2: Impact of passive and active passengers on the gut microbiome under digestive conditions
    - The concept of "passengers" refers to food components on the molecular scale that don't have a direct nutritional or health outcome, but which interact with other components for health and nutritional benefits (or the reverse, where nutrition and health are adversely affected).
    - Impact of processing on these passengers
    - Impact of changes in passenger content/levels on microbiome

4. *Consumer insights and engagement / Understanding the sensory space*

- Starting point should be understanding consumer wants and needs, to drive material and process selection within realms of what is feasible. Both sensory quality but also other extrinsic factors.
- We know sensory quality is a barrier but have no understanding of what is acceptable to who
- Need to model preference for “Asia” versus “Caucasian”/Polynesian and other population groups, not necessarily just cultural segments (nutrition quality, sustainability, taste, texture, source, etc.)
- Prototyping acceptance needs to include relevant factors: non-sensory (price pain points, formats, additives) and different sensory aspects (metabotypes, flavour, bioactives, satiation, chef testing - make it tasty)
- Consumer relevant messaging strategies: Government incentives? – what would work? Benefits that have more resonance – T2D, aging, exercise with which consumer groups
- Consumer aspects are the same irrespective of material and process
    - #1: Materials, processing, health, and consumer – what will work and should go into consumer test/insight
    - #2: Consumer insight feedback – inform what materials and processes have most chance of ‘final’ success (iterative process)
- Overall, project needs a holistic approach to understanding evolving consumer acceptance of alternative plant proteins alongside capabilities in materials and processing and clear evidence of health benefits.

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Discussions between scientists on forming partnerships

On day 2, participants were divided into smaller groups to discuss various elements of forming a partnership between Singapore and New Zealand:

What expertise do we have at the workshop?

- Lots of protein and materials scientists
- Singapore Food Agency
- Protein extraction
- Protein biochemistry
- Protein kinetics
- Membrane separation
- Characterisation (omics)
    - Metabolomics
    - Proteomics
    - Rheology (physical)
    - Chemical analysis
    - Whole-food system
- Functionality
- Thermal and non-thermal processing
- Extruding
- Fermentation
- Enzyme processing
- In vitro digestions
- Microscopy of digested food
- Food-matrix interactions
- Oral processing robotics
- Clinical trials
- Nutrikinetic modelling
- Non-animal models
- Gut microbiota
- Bioactivity
- Allergenicity
- Microscopy
- 3D printing
- Math modelling
    - Process model
    - Techno-economic
    - Gasto-intestinal
- Sensory analysis
- Pilot-scale
- Novel processing
    - Sonic
    - Fermentation
    - Sup. CO2
- Health outcomes: malnutrition, satiety (obesity), diabetes, metabolic health, CVD, allergies (skin), sarcopenia, immunology, dysphagia

What expertise is missing at the workshop?

- Land-use diversification
- Environmental impact
- Life-cycle analysis
- Biomass production (eg. seaweed)
- Food Standards Australia New Zealand (GMOs?)
- Oil and starch industries (plant protein often the byproduct of other industries)
- IP management
- Gut barrier function
- Health outcomes:, geriatrics, digestive diseases (IBS, intolerances), special diets, infant nutrition, sports nutrition

How to allow cross-fertilisation of ideas?

- Webinars
- Traditional + novel protein combinations
- Indigenous perspectives

Have we missed any key opportunities?

- Cellular agriculture
- Urban/vertical farming for protein
- Aquaculture/aquaponics

Ideation: Advancing programme goals

Finally participants were asked to provide ideas in response to the following questions:

How do we create a coherent programme?

- Identify themes, clear scope, country representation
- Well defined aim and outcome of the whole program (rather than multidisciplinary teams for their own sakes)
- Structured milestones and objectives
- Challenge statements
- Build programme before call for proposals
- Ensure clear connection between teams
- NZ-SG overall programme "gatekeeper"
- Core idea – full engagement of all partners → self-assembly
- NZ/SG post projects for the other to apply for
- Have small projects for individuals to apply (seed funds, catalyst funds) in addition to the big call
- Funding for workshops, external to project funding
- Focused teams, not too wide in scope
- Cohesion – use same samples across teams
- Structure of the call – to not dilute funding
- IP strategy
- Clear vision and objectives
- Clear framework → clear refocus points (and plan B)
- Avoiding 'pet' projects
- Communication – report back
- Plans for spin-out of products/tech outside of this research programme

- What does success look like? (and failure)
- Independent programme coordinator and science management team (funded separately to programme)
- Linkages between consumer, materials, processes, and health (integrated)
- Identify roles – who will do what

How do we ensure a balanced representation of scientists?

- Balance dictated by program focus and skillset
- People with specific role to ensure coherent balance of skills for successful outcomes
- Not top heavy with lots of principal investigators
- Agricultural – farmers, producers
- Requirement for % proportion to come from one of the participating countries
- Key representative per institute
- Mix of experienced and early career researchers on both sides (career development/leadership opportunities to increase capacity/capabilities)
- Aligning expertise
- Restrict any one proposal to cover all four themes
- Travel support between NZ and Singapore
- Expertise needs to match proposal
- Interdisciplinary – at least 2-3 disciplines
- Match numbers on each side
- Work to strengths

How do we ensure sustainability of the research relationships?

- Small teams
- Well defined aims, complementary skills/programs for same goal
- Shared postdocs, students, exchanges – also within SG/NZ
- Yearly reviews
- Symposiums periodically – all researchers meet face-to-face once a year
- Everyone takes ownership of the entire project to avoid compartmentalisation
- Student/researcher exchange
    - eg. A*STAR Research Attachment Programme, which funds non-Singapore PhDs to spend 1-2 years at A*STAR (currently under subscribed), could be leveraged to enhance collaborations funded by the Future Foods research programme
- Can we create a transnational PhD programme? (3 yrs for NZ, 4 yrs for SG)
- Create expertise groups between NZ-SG
- NZ-SG Science advisory group
- Annual workshop at programme level (in-person)

- Online workshops
- Earmark possible end of project follow-up funding
- Thinking beyond (economic, public health, society)
- Mentoring

How do we ensure engagement with industry?

- Industry advisory group
- Have industry collaborator if they bring a missing skill/component
- Involve them from the start → insights
- Use 3 yrs as a 'pilot' testing period → results/outcomes must be meaningful
- Focus on high quality science and spawn off aligned projects with industry where appropriate
- Let the research flourish for the first 3 yrs before involving others
- As soon as possible, especially regarding indigenous organisms (NZ context → partnership with Māori)
- Early engagement with industry partners, regular workshops to update
- Regular reporting to industry
- Showcasing to industry – trade fair
- Consultants from industry → early accessibility to technology/IP
- Understand/manage IP

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Appendix – Workshop Participants

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