Seaweed as a source of novel bioactives for gut and metabolic health

Emer Shannon[1, 2], Michael Conlon[2], Sarah Hotchkiss[3] and Maria Hayes[1]

[1] Teagasc, Food Biosciences Department, Ashtown, Dublin 15, Ireland.
[2] Commonwealth Scientific and Industrial Research Organisation, Kintore Ave, Adelaide, SA 5000, Australia.
[3] CyberColloids Ltd, Carrigaline Industrial Estate, Carrigaline, Co. Cork, Ireland.

Introduction

Hypertension, type-2-diabetes, and obesity are global metabolic health burdens[1]. These metabolic disorders are associated with dysbiosis of the gut microbiota – an imbalance or decreased diversity of beneficial versus harmful bacterial species[2]. The gut microbiota exerts an effect on immunity, metabolism, and neuroendocrine responses; and synthesises short-chain fatty acids, which have multiple important biological functions[3]. Seaweed is a sustainable source of novel bioactive compounds with potential to treat metabolic disorders and dysbiosis of gut microbial populations. However, there is limited published data on the impact of seaweed extracts on gut health and the effect of food processing on their bioactivity. This project will screen seaweed extracts for their impact on biomarkers of metabolic health *in vitro*; assess their potential as prebiotics for gut bacteria; and develop extracts with bioactivity into functional foods.

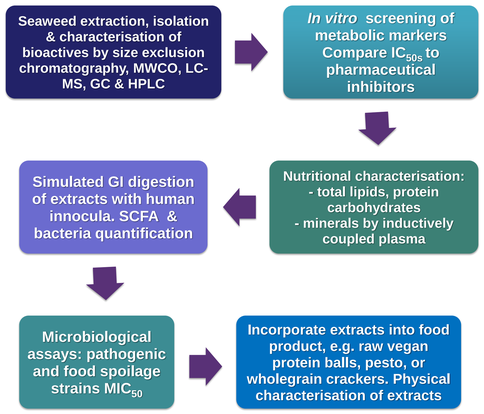
Table 1. Australian and Irish seaweeds under study

Class	Phaeophyceae	Chlorophyta	Rhodophyta
Australian	*Phyllospora comosa* (Crayweed) 	*Ulva lactuca* (Sea lettuce) 	*Asparagopsis armata* (Harpoon weed) 
Irish	*Alaria esculenta* (Atlantic wakame) 	*Ulva lactuca* (Sea lettuce) 	*Palmaria palmata* (Dulse) 

Methods

- Food-grade enzymes and solvents will be used to extract and fractionate polysaccharides, peptides and polyphenols from a range of brown, green and red Irish and Australian seaweeds.
- *In vitro* assays will measure their ability to inhibit angiotensin-1-converting (ACE1) enzyme to lower blood pressure, α-amylase to improve glycaemic control, lipase to reduce dietary fat absorption, and antioxidant capacity to inhibit free radical damage. IC_{50} values will be compared to pharmaceutical inhibitors Captopril, Acarbose and Orlistat.
- The impact of seaweed extracts on gut health will be evaluated by simulated *in vitro* gastrointestinal enzymatic digestion and colonic fermentation with human faecal innocula.
- Short-chain fatty acid (SCFA) production by gut bacteria in the *in vitro* system will be quantified by gas chromatography. Abundance and diversity of bacterial populations will be assessed by 16s rRNA sequencing.
- Extracts that exhibit bioactivity will be characterised by LC-MS and NMR.
- Compositional analysis of seaweed proteins, insoluble and soluble fibres, lipids, minerals and calorific value using AOAC methods.
- Functional foods will be developed with enhanced nutritional profiles while maintaining sensory acceptability. Physical characterisation of extracts will include viscosity, solubility, interactions with other ingredients, stability during storage and the impact of cooking on bioactivity.

Fig. 1. Project workflow



Impact

The expected impact of this project will be the production and characterisation of seaweed components which can:

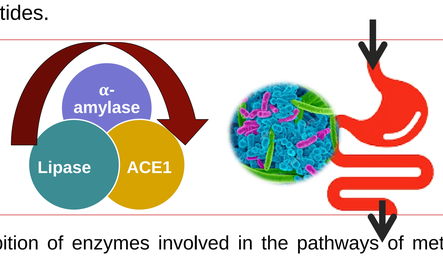
- Inhibit enzymes that contribute to metabolic disorders
- Act as prebiotics for gut bacteria to alleviate dysbiosis
- Be developed as nutraceutical food products or supplements

Prescription drugs for metabolic disorders commonly cause side effects such as persistent cough, gastrointestinal disturbances, pruritus, and valvopathy[4] which have not been reported for seaweed-derived products.

In addition, a comparison of the bioactivity of Australian versus Irish seaweeds has not been previously reported.

Fig. 2. The impact of seaweed extracts on gut and metabolic health

- ***Polysaccharides***: Fucoidan, laminarin, alginate (brown), ulvan (green), & porphyran (red).
- ***Polyphenols***: Phlorotannins (brown), flavonoids (green), & bromophenols (red).
- ***Peptides***:
  High protein content of seaweeds produces bioactive peptides.

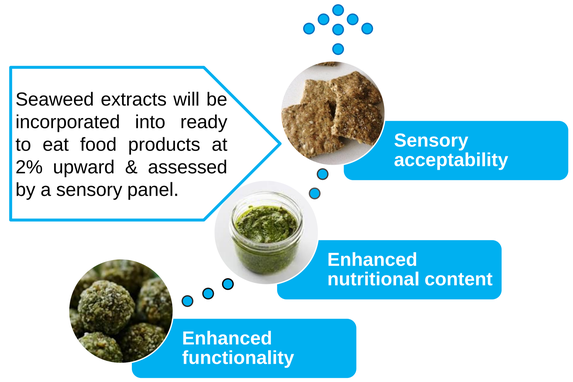


- ✓Inhibition of enzymes involved in the pathways of metabolic syndrome.
- ✓Increased abundance & diversity of gut bacteria.
- ✓Enhanced production of SCFA by gut bacteria which modulate intestinal barrier integrity & function; and induce secretion of gut hormones glucagon-like peptide, serotonin & γ-aminobutyric acid via enteroendocrine cell interaction[5].
- ✓Positive modulation of intestinal epithelial cell differentiation & immune function[6].

Conclusions

Despite evidence of the health benefits of raw seaweed consumption, its organoleptic properties are not widely accepted in Western cultures[7]. Incorporating seaweed extracts into ready to eat foods has the potential to bring the nutritional benefits of seaweed to a greater number of consumers. The outcomes of this project will contribute to advancements within the research field of seaweed nutrient bioavailability and potentially generate growth and increase value-added output for the marine processing and ingredients sector.

Fig. 3. Functional and nutritional enhancements to foods



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