Team Name:

UC Davis Giant Kelp Team

Team Schools/Organizations:

University of California Davis, Davis, CA

Abstract:

The escalating pressure on existing production systems due to an increasing world population, limited availability of arable land, and increasing atmospheric carbon dioxide concentration has prompted the search for sustainable sources of macro-and micronutrients for use in industrial applications. Macroalgae or seaweeds are macroscopic marine algae that have been traditionally consumed in Asian countries for centuries. Because of its composition, wide availability, and growth associated environmental benefits (i.e. carbon sequestration, support to fishery habitats, and reduced dependence on freshwater, arable land, and fertilizer) macroalga has been highlighted as a sustainable biomass feedstock for the production of a wide range of carbohydrates (i.e. laminarin, fucoidans, alginate), growth hormones, proteins, and phenolic compounds (phlorotannins). These have the potential for use in human nutrition, animal feed, production of bio-stimulants or fertilizers for plant growth, biotherapeutic, cosmetic, and food applications. However, full utilization of macroalgae's potential relies on the development of sustainable bio-guided downstream processing strategies that make use of structure and functionality as the benchmark for the development of processes capable of not only maximizing the extractability of its diverse compounds but also preserving the functional and biological properties of the algae extracts. The major goal of this research project is to elucidate the impact of key processing conditions (i.e., solids-to-liquid ratio, temperature, pH, time, enzyme use) and methods on the extractability, structural composition, and functional/biological properties of major compounds of the giant kelp species Macrocystis pyrifera, typically found in the Pacific Ocean, to develop effective and sustainable structure/function-based extraction methods to produce algae compounds with the desired properties. Various seaweed-derived oligosaccharides (alginate, laminarin, and fucoidan) have been proposed to possess interesting bioactive properties in both in vitro and in vivo systems, yet they present a formidable analytical challenge in terms of characterization, which limits our current understanding of the

mechanisms of action associated with the extraction of these carbohydrates. The specific goals of this project are to: 1) investigate the effectiveness of environmentally friendly, flammable-solvent free, aqueous and enzymatic extraction processes and their integration with microwave-assisted processing (suitable for wet-based biomass extraction) with respect to the extraction yields of Macrocystis pyrifera compounds (proteins, carbohydrates, phlorotannins); and to 2) elucidate the impact of important extraction parameters on structural composition and functionality of the extracted compounds to develop a downstream biorefinery strategy able to enhance the extractability of several biomass compounds (i.e. proteins, fucoidans, and phenolics) with the desired functional/biological properties (i.e. antioxidant activity, prebiotic, antimicrobial, and emulsifier properties) to maximize process sustainability and efficacy. To accomplish this goal, advanced mass spectrometry methods will be used to characterize the impact of key processing conditions on proteins and carbohydrates. The overall composition of carbohydrates will be first assessed by performing acid hydrolysis to characterize and quantify the composing monosaccharides by LC-QQQ mass-spectrometry, and then extracts will be additionally analyzed for oligosaccharides in the range of 2-20 units of degree of polymerization by nanoLC-Chip-Q-ToF and MALDI ToF. Peptides obtained from trypsin digestion will be analyzed on nanoLC-Chip-Q-ToF, and proteins will be identified using the Swiss-Prot database and PEAKS Studio X Pro. Functional and/or biological properties of the extracts produced will be used as the major benchmark for the selection of the best processing conditions to produce more functional algae extracts.