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Date: 24th October 2019
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EU ALGAE: The European Network for Algal Bio-Products

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Key external stakeholders:

Scientists (early stage and mature), researchers, algal processors and producers as well as food and feed industries interested in the use of microalgae as an alternative source of proteins, lipids, carbohydrates and food and feed ingredients and as ingredients in the food, pharmaceutical and chemical industries. The project looked at best practices for the bio-refinery of microalgae for food, feed, fuel and chemical applications.

Practical implications for stakeholders:

Fossil fuel covers the majority of our energetic and chemical needs. However, fossil fuels are limited and the petrochemical industry has a negative impact on the environment. Biomass, as a renewable source, is attracting worldwide attention to satisfy this demand in the so-called bio-economy. Conventional biomass feed-stocks remain controversial due to the limited land availability and competition with food and feed production. Microalgae represent a promising alternative renewable source since they can be cultivated on non-arable land. Furthermore, microalgae remove and recycle nutrients from wastewater and flue-gases, thus providing additional environmental benefits. Investigating the production of non-fuel products could play a major role in turning economic and energy balances more favourable. Microalgae offer interesting applications in the nutrition field being high in protein, antioxidants, pigments, polyunsaturated fatty acids and small molecules. EUALGAE (Cost Action ES1408) proposed the establishment of a European network sharing a common goal: development of an economical feasible model for the commercialization of algae-based bio-products. EUALGAE created interaction among research groups across Europe but also fostered cooperation between academia and industry. This scientific platform generated a synergistic approach for utilisation of microalgae biomass for sustainable fuels and fine chemical products. Microalgae accumulate a variety of compounds that form the basis for potential marketable products as whole cell biomass or as fractions after an extraction process. A cascading bio-refinery approach aims at recovering and separating multiple algae compounds to valorise the complete biomass and to improve the economics of the value chain. Teagasc participation in EUALGAE focussed on the development of extraction and characterisation processes and current and potential applications, markets, and legislation surrounding the use of microalgal proteins as food, feed, and functional food products and ingredients.

- Bio-refinery approaches were developed for the generation of proteins and small molecules from selected microalgae.
- Bottlenecks concerning the use of microalgae as food and feed ingredients were identified and relayed to CEN (responsible for legislation development on algae use in the European Union).

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- Food products where developed where microalgae were included for their functional food and health benefits.
- A European network of research scientists and industry partners was developed which included 61 researchers from 21 countries.
- The technofunctional and potential health attributes of microalgae and microalgal derived bioactives, specifically proteins and peptides were identified.
- Algal protein isolated from *Spirulina* sp. and *Isochrysis* sp. was determined as suitable for use in alkaline drinks such as tomato juices to increase the essential amino acid profile and protein content.

Main results:

• A scheme for isolation of novel bioactives and proteins from microalgal was developed (Figure 1).

• The protein content of the generated extracts isolated from Spirulina platensis and Isochrysis galbana T-Iso were calculated following analysis using the LECO method with a total nitrogen conversion factor of 4.4 as recommended previously. Extracts were found to contain 85.5 ± 4.9% and 71.9 ± 8.6% protein, respectively. Marine microalgae were identified as an alternative protein source suitable for use in the generation of protein isolates and hydrolysates for the functional food industry with additional health benefits including ACE-I inhibition (suitable for control of hypertension).

• The amino acid profile of proteins extracted from Spirulina sp. and Isochrysis sp was determined and the essential to non-essential amino acid ratio of both algal proteins were similar to that of soy and flaxseed protein. The total amino acid content of Spirulina sp. protein extract was determined as 314.72 g/kg DW and the content of Isochrysis sp. was determined as 257.06 g/kg DW with the essential amino acid composition approximately 69.32 % of the total amino acid composition for Spirulina sp. and 43.56 % for Isochrysis sp., respectively (Figure 2).

• The technofunctional characteristics of algal proteins were determined and were found to be soluble at alkaline pH values and had excellent foaming capacities. The foaming capacity and stability values observed for both microalgal protein extracts, along with their solubility at pH 10-12 and excellent OHC values, suggest that these proteins could be used in the formulation of a wide variety of foods with alkaline pH values with an oil consistency such as green drinks with a pH greater than 9.5 and tomato juices. In addition, the excellent amino acid profile of these proteins and the presence of all of the essential amino acids suggest that they may also be used as functional/nutritional ingredients. However, the presence of contaminants and anti-nutritional factors as well as allergens should be evaluated.

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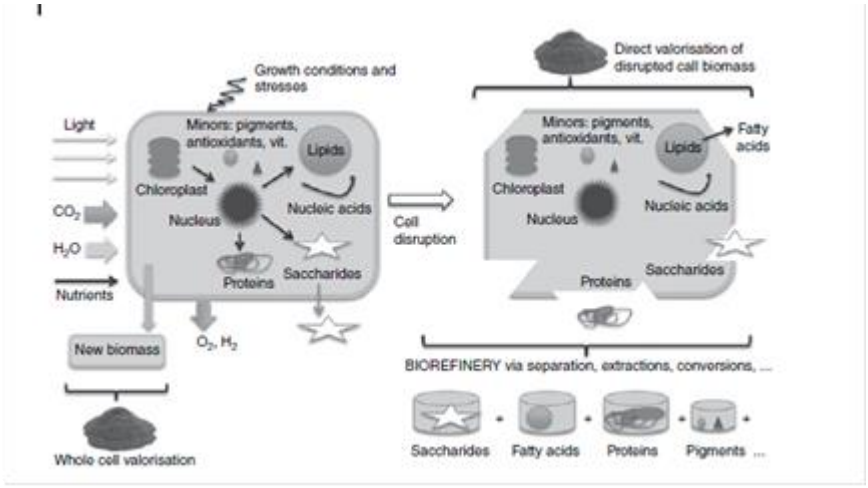

Figure 1: Schematic representation of microalgal valorisation options

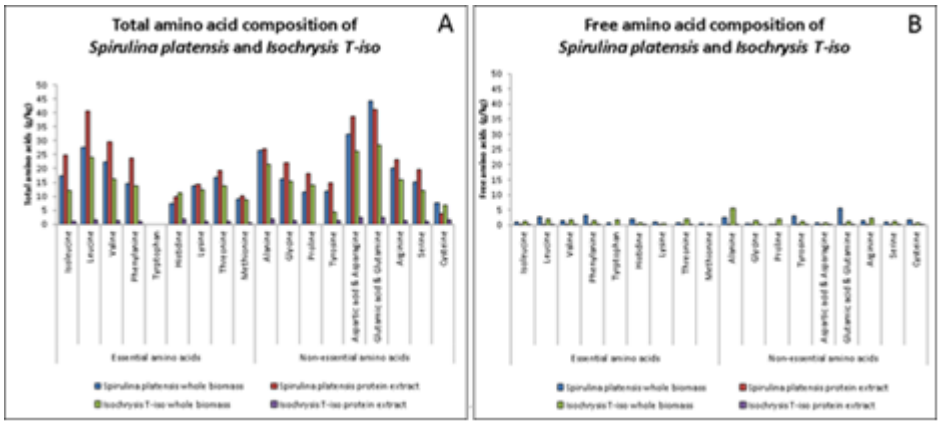

Figure 2: Total and Free amino acid composition of *Spirulina platensis* and *Isochrysis* T-iso proteins.

Opportunity / Benefit:

The project demonstrated how proteins and other small molecules can be harvested from microalgae for use in food and feed as well as pharma as part of a biorefinery process. Methods to overcome the main bottlenecks of the bio-refinery approach in the downstream processing of micro-algal high-value products such as PUFAs, antioxidants, proteins and pigments were developed for use by interested industry.

Collaborating Institutions:

IMDEA Energy, University of Copenhagen, University of Valladolid, Ege University, Universidad de Lisboa, NIBIO, University of Florence, Leuven University.

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Teagasc project team: Dr. Maria Hayes (PI)

External collaborators:
Dr Cristina Gonzalez
IMDEA Energy

Prof. Raul Munoz,
University of Valladolid

1. Project background:

Refining of microalgae into value components. The aim of EUALGAE was defined as evaluating techniques to overcome the main bottleneck of the bio-refinery approach in the downstream processing of micro-algal high-value products such as PUFAs, antioxidants, proteins and pigments.

2. Questions addressed by the project:

- What methods can be used to isolated proteins and small molecules from microalgae?
- What algae can be used in a bio-refinery approach for food, feed and fuel?

3. The experimental studies:

The aim of this project was defined as evaluating techniques to overcome the main bottleneck of the bio-refinery approach in the downstream processing of micro-algal high-value products such as PUFAs, antioxidants, proteins and pigments.

4. Main results:

- A scheme for isolation of novel bioactives and proteins from microalgal was developed (Figure 1).
- The protein content of the generated extracts isolated from Spirulina platensis and Isochrysis galbana T-Iso were calculated following analysis using the LECO method with a total nitrogen conversion factor of 4.4 as recommended previously. Extracts were found to contain 85.5 ± 4.9% and 71.9 ± 8.6% protein, respectively. Marine microalgae were identified as an alternative protein source suitable for use in the generation of protein isolates and hydrolysates for the functional food industry with additional health benefits including ACE-I inhibition (suitable for control of hypertension).
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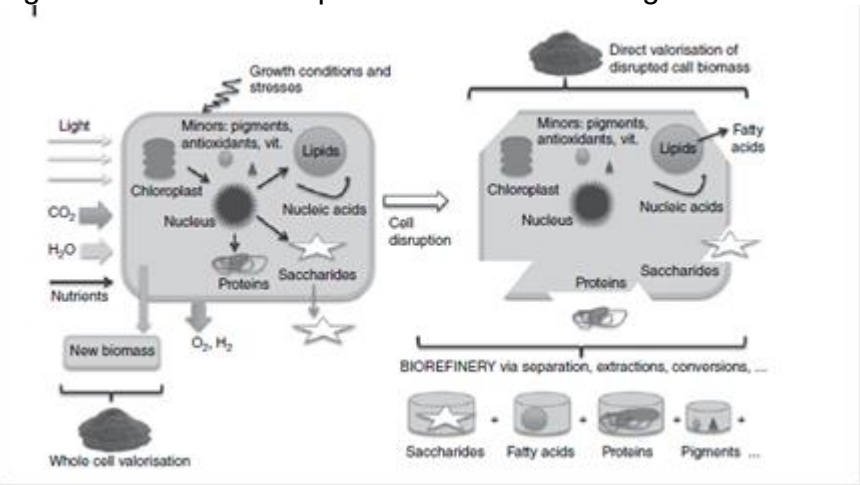
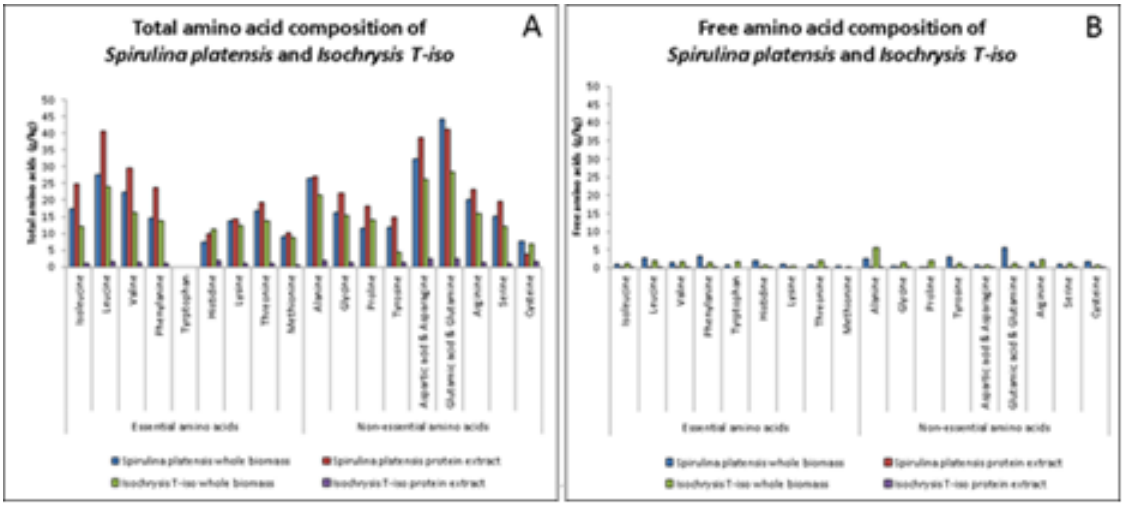


Figure 2: Total and Free amino acid composition of Spirulina platensis and Isochrysis T-iso proteins.



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5. Opportunity/Benefit:

Methods were developed for the downstream processing and utilisation of microalgae for food and pharma use. Companies can access this information, develop new products and potentially expand their markets by contacting researchers on EUALGAE.

6. Dissemination:

Main publications:

- Maria Hayes, Leen Bastiaens, Luisa Gouveia, Spyros Gkelis, Hanne Skomedal, Kari Skjanes, Patrick Murray, Marco García-Vaquero, Muge Isleten Hosoglu, John Dodd, Despoina Konstantinou, Ivo Safarik, Graziella Chini Zittelli, Vytas Rimkus, Victória del Pino, Koenraad Muylaert, Christine Edwards, Morten Laake, Joana Gabriela Laranjeira da Silva, Hugo Pereira, Joana Abelho (2018)'Microalgal Bioactive Compounds Including Protein, Peptides, and Pigments: Applications, Opportunities, and Challenges During Bio-refinery Processes. In: Novel Proteins for Food, Pharmaceuticals and Agriculture: Application and Advances', (Hayes, M., Ed.), John Wiley and Sons, Ltd., 2019, pp. 239-255.

- Maria Hayes (2016) 'EUALGAE: Microalgae proteins and ingredients' T-Research, Volume 11: Number 1. Spring 2016, 32-33.

- Lorenzo Hernando, A., González, A. M., Boladoa, S. * and Hayes, M. (2019).Performance of a combined protein recovery process for Scenedesmus sp., biomass by enzymatic hydrolysis and evaluation of the techno-functional properties of the extracts. Algal Research.

- Short term scientific missions (STSM): A PhD student (Anna Lorenzo Hernando) from the University of Valladolid was hosted by Teagasc Food Research Centre, Ashtown for durations of 6 (September 2016-February 2017) and 3 months respectively (04 October 2017 – 22 December 2017).

- Teagasc researcher Dr Maria Hayes participated in EUALGAE workshops held in Lisbon (September 2017), Athens (March 2018), Madrid (February 2019), Florence (September 2018) and Dublin (November 2015).

- One popular article and 2 scientific publications were produced during the course of EUALGAE at Teagasc.

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