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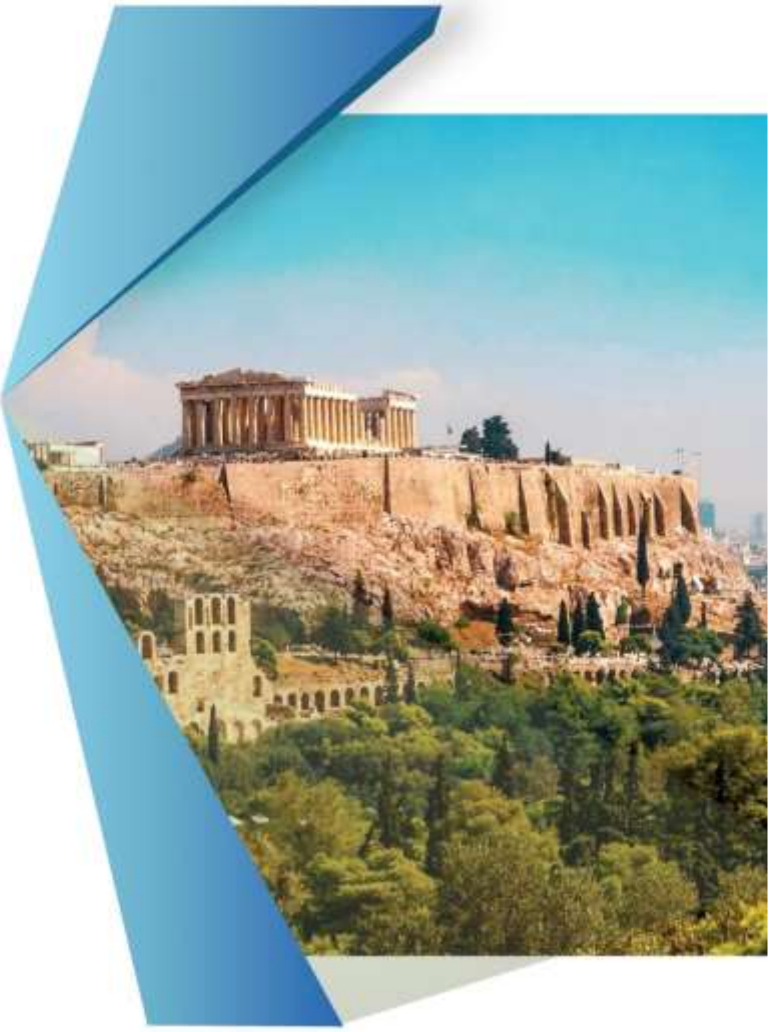

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CONTACT INFORMATION
GreenIUPAC 2022 Secretariat

www.greeniupac2022.org

info@greeniupac2022.org

+30 2310 528978

Enotikon 10 Thessaloniki, Greece, GR - 54627

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. BlueBio mass valorization through analytical techniques for the quest of biostimulants in plant growth

Matsia, S.[1*] Maroulis, M.[1,2] Perikli, M.[1,2] Parvulescu, O.C.[3] Ion, V.A.[4] Løes, A.-K.[5] Cabell, J.[5] Salifoglou, A.[1]

[1] *Laboratory of Inorganic Chemistry and Advanced Materials, School of Chemical Engineering, Aristotle University of Thessaloniki, Thessaloniki 54124, Greece*

[2] *Modern Analytics Testing Laboratories, Thermi 57500, Thessaloniki, Greece*

[3] *Chemical and Biochemical Engineering Department, University Politehnica of Bucharest, 1-3 Gheorghe Polizu, Bucharest, Romania*

[4] *Research Center for Studies of Food Quality and Agricultural Products, USAMV, 59, Marasti Blvd., Bucharest 011464, Romania*

[5] *Norwegian Centre for Organic Agriculture (NORSØK), Gunnars veg 6, Tingvoll N-6630, Norway*

**E-mail: srmatsia@cheng.auth.gr*

Abstract

Significant research and innovation activities, all over the world, have been and are currently being carried out to develop high-value products for pharmaceutical or nutritional purposes. This universal drive has led to the establishment of a new industry, however, there are still appreciably valuable residual materials, which are underused, emerging especially from the capture of wild fish, raising fish in aquaculture, and the seaweed and shellfish industries [1].

The importance of BlueBio materials in agricultural activities, targeting new fertilizers and biostimulants of plant growth, attract keen interest from the scientific community. There are different types, defined as biostimulants, including humic acid (HA) and fulvic acid (FA), protein hydrolysates (PHs), seaweed extracts, chitosan, inorganic compounds, beneficial fungi, and bacteria. The primary sources of biostimulants also reflect origin and physiological characteristics, much the same way as the ones extracted from macro- and micro-algae [2,3,4].

Bearing in mind the ambitious goals of the European Union about the organically-driven management of agricultural land, to be reached by 2030, and the economic significance of such products to the entire continent, this project aspires to study available residual materials from fish capture, the brown algae industry, the mussel industry, and organic aquaculture. Relevant materials were provided by five Scandinavian industry partners (**Figure 1**). The materials are chemically characterized and compounds with potential biostimulant effects on crop plants are to be investigated, while concurrently checking for possible biotoxicity.

The goal, therefore, is the development of expert analytical tools in the characterization of Low and High Nitrogen Algal Cake and possibly other marine-derived residual products. Parameters include cellulose content, for which a classical Weende-based approach have been implemented. The Macro and Micro Nutrients, including K, Ca, Mg, P, Fe, Mn, etc., as well as potential toxic elements (PTEs) As, Cd, Cr, Hg, Pb have been perused through Inductively Coupled Plasma (ICP) methodologies. Key to such an endeavor is sample preparation, involving dry ashing as well as microwave assisted digestion. PTEs are also determined via ICP-MS approaches, thus seeking to achieve lower levels of detection. Moreover, screening for organic compounds emerges prominently in the study and is pursued through GC-MS methods on extracts of varying polarity solvents. Using those extracts, the lipid content in the title materials is explored through GC-FID. Collectively, promising materials (assessed through chemical characterization) will be tested under real growing conditions in greenhouses and fields. The logistics and related costs required for establishing a relevant value chain for producing fertilizers and/or biostimulants will be assessed by interviewing collaborating industry partners and surveying potential customers.

Materials and Methods

Methods used for extractions of raw materials include the following: Accelerated solvent extraction (ASE) and GREEN solvent (e.g. ethanol, ethylacetate, hydrotrope mixtures, ionic liquids), ultrasonic assisted extraction and microwave assisted extraction. Extracts obtained through the above processes have been analyzed for their elemental composition and organic compounds composition [GC-MS, LC-ESI-MS, (^{1}H, ^{13}C)-NMR, FT-IR]. The desired compounds expected to appear include antioxidants, organic acids, proteins, amino acids, PUFAs, etc., depending on the nature of the raw materials used.

Figure 1: Raw materials from BlueBio resources

Results

Our efforts to identify the various components of raw materials, including low nitrogen seaweeds (LNSW), high nitrogen seaweeds (HNSW) and grinding fish residues (GFB), started by determining total C, N concentration of the samples, and protein-fat content, with the results shown in **Table 1**.

Table 1: Total carbon, hydrogen and nitrogen

Analysis	LNSW	HNSW	GFB
Total C %	12.1	12.1	7.85
Total N %	0.16	0.42	2.05
Protein %	1.0	2.6	12.8
Fat %	2.3	1.5	0.2

The collective results formulate a well-defined profile for both Low and High Nitrogen Algal Cake materials, thus signifying the importance of a) screening for key ingredients in raw materials, and b) identification of both organic and inorganic components in algal materials, which could be used in agricultural practices for crop plant growth enhancement. It is worth emphasizing the fact that past studies have shown a positive effect of high N algal cake on ryegrass growth [5]. What boosted production of dry matter with algal cake, across five harvests, higher than non-fertilized soil control, was a long-term effect, with yields maintaining a quite stable level even in the final harvest and control yields leveling off. In the final harvest, the yield with algal fiber was higher than that with the same amount of N applied in mineral N fertilizer (Calcinit). The algal cake has a rather slow, yet long-term growth effect.

Poised to pursue the physicochemically and biologically supported effort for the search on crop plant biostimulants, the presently ongoing research attests to the importance of raw materials of marine industries in their added value as BlueBio products in contemporary agricultural activities and beyond.

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