SUSTAINABILITY ASSESSMENT OF A MULTI CIRCULAR MODEL CONSIDERING POLYCHAETES AS AN EFFECTIVE FISHMEAL ALTERNATIVE FOR AQUACULTURE AND EXPLOITATION OF AQUACULTURE SIDESTREAMS TO OBTAIN VALUABLE PRODUCTS SUCH AS ASTAXANTHIN, VIA BIOCONVERSION PROCESS.

M. Perucca[1*], S.A. Aldaghi[1], M. Costamagna[1], R. Ubais[1], I. Schmitt[2], F. Meyer[2], I. Krahn[2], N.A. Henke[2], P. Peters-Wendisch[2], V.F. Wendisch[2], M. Monteiro[3], R.S. Costa[3], V. Sousa[3,4], A. Marques[3], T. Sà[3], L. Thoresen[5], K. Kousoulaki[5], L.M.P. Valenete[3,4]

[1] Project HUB-360, 10051 Avigliana (TO), Italy; [2] Institute for Genetics of Prokaryotes, Faculty of Biology and CeBiTec, Bielefeld University, 33615 Bielefeld, Germany; [3]CIIMAR, Centro Interdisciplinar de Investigação Marinha e Ambiental, Universidade do Porto, Terminal de Cruzeiros do Porto de Leixões, Av. General Norton de Matos, S/N, 4450-208, Matosinhos, Portugal; [4]ICBAS, Instituto de Ciências Biomédicas de Abel Salazar, Universidade do Porto, Rua de Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal; [5]Nofima, Nutrition and Feed Technology department, Kjerreidviken 16, 5141 Fyllingsdalen, Norway
Email: massimo.perucca@project-sas.com

Introduction

As the aquaculture sector continues to expand rapidly, there is a growing emphasis on the implementation of sustainable methods in fishmeal preparation and waste management practices. In recent years, the pursuit of sustainable aquaculture practices has focused on alternatives to fisheries-derived ingredients, in order to reduce economic and environmental burdens. Low-trophic organisms, such as polychaetes (that may be fed on aquaculture side streams), could be a suitable partial alternative to fishmeal due to their high protein content. Furthermore, aquaculture side streams may be better exploited for enabling bioconversion processes yielding valuable bio-based chemicals, including astaxanthin as pigment with antioxidant properties, which is widely used in various industries, including food and pharmaceuticals. The demand for astaxanthin has led to the development of multiple production methods, including algal, bacterial, and synthetic approaches. In this work, we perform the environmental sustainability assessment of a multi-circular model. The analysis includes polychaete-based fishmeal (PM) production and seabass feeding trials compared with conventional best fish meal (FM) formulations, and a comparative analysis between two alternative bio-conversion methods to obtain astaxanthin: the bacterial bio-conversion process employing aquaculture side streams and the algal bio-conversion process. Both polychaetes-based diets and side streams fed bacteria bio-conversion process prove to be more sustainable alternatives with respect to current solutions relying on linear economy model, thus enabling a multi-circular value chain.

Materials, methods and results.

To address the sustainability issues associated with fishmeal, various alternatives have been investigated. One of these alternatives is polychaete meals (PM) that offer a well-balanced nutritional profile, high protein content, and omega-3 fatty acids.

In order to assess the environmental sustainability of using polychaete meal (PM) as a substitute for fishmeal (FM) in diets for European seabass, the Life Cycle Assessment (LCA) analysis has been performed for the production of 50kg of FM, considering four experimental diets, which were formulated with varying levels of PM, replacing 0%, 10%, 20%, and 40% of standard fishmeal, referred to as FM, PM2.5, PM5, PM10, respectively. Environmental impacts have been normalised based on the result of the growth trials, which have been conducted by CIIMAR [1]. The assessment was performed referred to the diet functional key performance indicator represented by the Protein Efficiency Ratio

defined as: (PER) = (W_f − Wi) / (total protein intake (g)), where W_i and W_f are the initial and final weights.

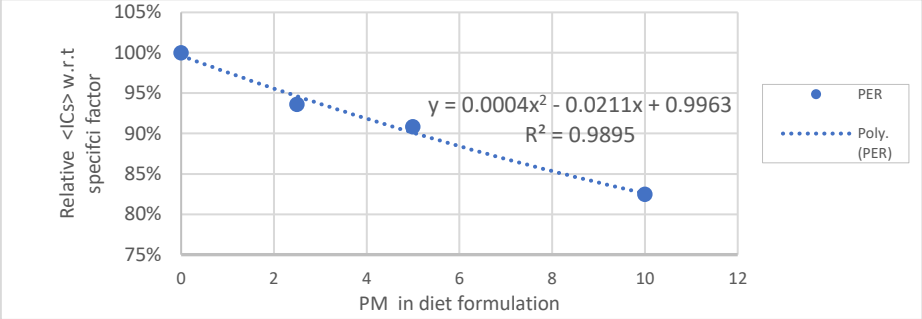

Figure-1: TU vs. FU of 4 feed formulations improvements trends

According to the trendline in Figure 1, which represents the average impacts per FU as a function of the PM rate (PM=0, corresponds to pure FM) indicates that an increasing inclusion of PM dramatically reduces the diet environmental impact profile. The feed trials through the addressed KPI prove that proposed PM diets are technically feasible, thus reinforcing the sustainability claim of the PM circular solution.

Considering the significant increase in the consumption of aquatic foods, it is imperative, from environmental perspectives, to efficiently utilize by-products generated in the aquaculture sectors. Starting from this principle Schmitt [2] suggested an innovative bacterial astaxanthin production process by C.glutamicum employing aquaculture side streams. Our dedicated LCA provided the comparative assessment between the two main sources for producing natural astaxanthin: bacteria and algae bioconversion processes. Figure 2 shows that the bacterial astaxanthin production using renewable energy and aquaculture side stream looks to be a promising solution to enable multi-circular blue-economy schemes. This approach shows a dramatic decrease of environmental impacts on all represented categories compared to the algal production method, with the exception of the aquatic toxicity and eutrophication potentials, in which algae solution display negative values. Furthermore, this circularity framework for producing astaxanthin incorporates aquaculture side streams as a sustainable nutrient source, therefore the burden of waste management and its associated environmental consequences can be avoided, while supporting the astaxanthin production process within the circularity framework also may turns costs into economic exploitable valuable.

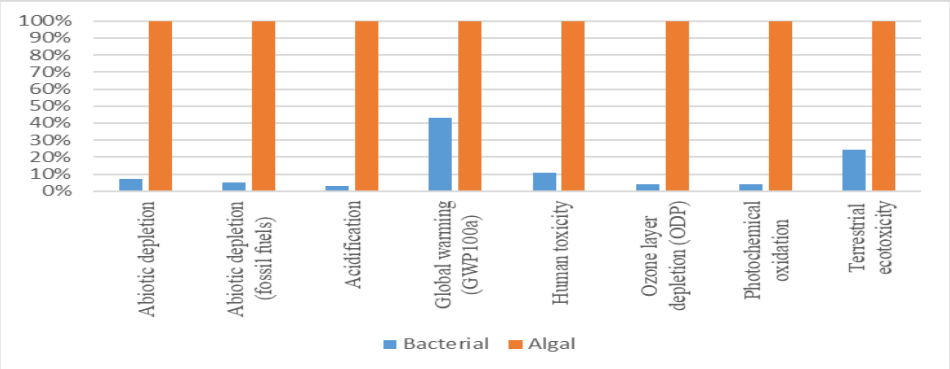

Figure-2: Comparative assessment between the two bacteria and algae-based bioconversion processes to produce astaxanthin.

References

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