RETASTE Conference Abstracts
Vol. 3 RETASTE-AFR-346-Oral
Athens, Greece, 27-29 September, 2023

rethink food resources, losses, and waste 2023 retaste

Heterotrophic growth of Galdieria sulphuraria on residues from aquaculture and fish processing industries

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Abstract

Residues from food and feed processing but also organic waste streams have been intensively investigated as nutrient sources in biotechnological processes. The overall goal was to utilise organic material instead of disposing it. Biotechnological processes allow for the formation of a broad range of products such as organic acids, bioplastics, proteins, or whole cell biomass which can even be applied for food and feed purposes. Depending on the composition different utilisation approaches need to be developed. In the past, the focus was mainly on carbon sources to be recovered and used in biotechnological processes. Nowadays, the focus has been shifted to the use of nitrogen compounds such as proteins and amino acids. This is due to environmental issues linked by its uncontrolled decomposition if not properly handled, but also due to the value of organic nitrogen compounds and the urgency of using it responsibly in circular concepts. The microalga *Galdieria sulphuraria* has been shown to grow on various hydrolysates of organic waste streams and to take up as well as use recovered nutrients for biomass formation. Thus, it was hypothesized that *G. sulphuraria* might also be suitable to convert waste streams appearing from aquaculture and fish processing industries. *G. sulphuraria* is due to its carbohydrate and protein contents highly wanted by respective industries. In the present study wastewater from fish processing, sedimented feed and faces collected from aquaculture ponds, and left-overs from the proteolytic hydrolysis of fish residues have been investigated as nutrient source in *G. sulphuraria* cultivation. The aim was to recover carbohydrates as carbon sources, amino acids as nitrogen sources as well as phosphate to establish a *G. sulphuraria* cultivation. Due to the nitrogen- and phosphate-rich composition of the used waste streams, the focus was on the recovery of nitrogen and phosphorous compounds. Results of this study revealed that from waste streams appearing from fish processing more than 1 g L^{-1} free amino nitrogen (FAN) and 1 g L^{-1} phosphate can be recovered by hydrolysis. *G. sulphuraria* did grow well on the produced hydrolysate and in presence of glycerol, another stream from fish processing, and growth rates of 0.7 to 1.0 day^{-1} were obtained. However, it should be admitted that G. sulphuraria required a proper composition of the nutrient medium. It was shown that the FAN and glycerol concentrations should not exceed 0.5 g L^{-1} and 20 g L^{-1}, respectively, to avoid a long lag-phase. To overcome this drawback and to achieve a high biomass

concentrations fed-batch cultivation has been carried out, which resulted in a *G. sulphuraria* dry biomass concentration of more than 70 g L^{-1}. The outcomes of this study are expected to contribute towards an efficient utilization of aquaculture waste streams and a circular aquaculture economy. The controlled recycling of organic waste streams and the avoidance of an uncontrolled decomposition of nitrogen-rich materials contributes to a reduced environmental impact of aquacultures.

Keywords: Protein residues, Bioeconomy, Algal biomass, Bioprocess, Fish processing

Acknowledgments: The authors acknowledge the German Federal Ministry of Food and Agriculture for providing funding within the Era-Net Cofund “FOSC-ERA” (Project Climaqua 2821ERA12) Program.