Research Program

For activation within the PhD Course in Applied Biology and Experimental Medicine of the following Research Program, using the resources referred to in Ministerial Decree no. 351/2022., relating to the following measure:

☒ **M4C1- Inv. 4.1** *"Estensione del numero di dottorati di ricerca e dottorati innovativi per la pubblica amministrazione e il patrimonio culturale".* In particolare:

☐ **Dottorati PNRR**

Title of the research program: Enhancement of by-products from the fishing industry

❖ **Description:**

Fisheries-related activities generate significant amounts of by-products, which are often disposed of or used as low-value ingredients in animal feed [1]. In 2016, world fish production was approximately 171 million tonnes, of which 91 million tonnes came from inland and marine fisheries and 80 million tonnes from aquaculture [1]. A large quantity of fish by-products is generated each year because of the activities related to the different fishing sectors, ranging from 30% to 85% of the weight of the different catches; and these by-products are not used for direct human consumption [2]. This fishery by-product has a great ecological impact and, also significantly affects the economic viability of the fisheries and aquaculture sector [2]. These by-products represent a potential source of bioactive compounds with important functional properties of interesting use in the nutraceutical and pharmaceutical industries. In particularly, up to 10-20% (w/w) of the total fish protein is found in by-products and the crude protein content of these ranges from 8 to 35% [2]. By refining fish by-products, components with high added value can be obtained. In particular, the processing of fish protein can generate bioactive peptides, amino acids, and other bioactive nitrogen compounds [2]. There are many possibilities to valorise marine by-products, and the choice of appropriate extraction methods for each bioactive component is of utmost importance to be able to use marine resources responsibly and correctly [2]. Retaining the waste and by-products of marine capture and aquaculture in the food chain can be practised either through the commercialisation of low-value fractions or through the production of ingredients and biomolecules of high biological value that can be used in the pharmaceutical and nutraceutical industry, which satisfies the principles of a sustainable circular economy. This approach allows a rational use of fishery and aquaculture by-products, turning them into ingredients that can be incorporated into feed, food, or other high-value products. Indeed, it is known that compounds derived from fish by-products induce positive effects on human health, promoting anti-tumour, antidepressant, antidiabetic, antihypertensive, anti-inflammatory, antimicrobial, antioxidant, and immunomodulatory activity [3-6]. Various techniques can be used to extract bioactive compounds, thus enhancing the value of fish by-products, including enzymatic hydrolysis, which enables the solubilisation and concentration of fish-derived proteins, while maintaining the nutritional value of the protein of origin [1-2]. There is therefore great interest within the scientific community in the valorisation of fish by-products due to their high nutritional value, representing an environmentally sustainable strategy with positive consequences for both the producing fishing industry and human health. The fish by-product valorisation strategy based on the development of new products can lead to a more environmentally sustainable use of marine resources and greater economic benefits for the sector. It is therefore crucial to define appropriate extraction technologies that minimise processing, maximise quality and yield, and ensure product safety, therefore meeting sustainable development goals in achieving food security and safety for the increasing global human population.

1. Al Khawli F et al. Innovative Green Technologies of Intensification for Valorization of Seafood and Their By-Products. Marine Drugs. 2019, 17, 689.
2. Chalamaiah, M.; Dinesh kumar, B.; Hemalatha, R.; Jyothirmayi, T. Fish protein hydrolysates: Proximate composition, amino acid composition, antioxidant activities and applications: A review. Food Chem. 2012, 135, 3020–3038.
3. Drotningsvik, A.; Mjøs, S.A.; Pampanin, D.M.; Slizyte, R.; Carvajal, A.; Remman, T.; Høgøy, I.; Gudbrandsen, O.A. Dietary fish protein hydrolysates containing bioactive motifs affect serum and adipose

tissue fatty acid compositions, serum lipids, postprandial glucose regulation and growth in obese Zucker fa/fa rats. *Br. J. Nutr.* **2016**, *116*, 1336–1345.
4. Parolini, C.; Vik, R.; Busnelli, M.; Bjørndal, B.; Holm, S.; Brattelid, T.; Manzini, S.; Ganzetti, G.S.; Dellera, F.; Halvorsen, B.; et al. A Salmon Protein Hydrolysate Exerts Lipid-Independent Anti-Atherosclerotic Activity in ApoE-Deficient Mice. *PLoS ONE* **2014**, *9*, e97598.
5. Giannetto, A.; Esposito, E.; Lanza, M.; Oliva, S.; Riolo, K.; Di Pietro, S.; Abbate, J.M.; Briguglio, G.; Cassata, G.; Cicero, L.; et al. Protein Hydrolysates from Anchovy (*Engraulis encrasicolus*) Waste: In Vitro and In Vivo Biological Activities. *Mar. Drugs* **2020**, *18*, 86.
6. Bjørndal, B.; Berge, C.; Ramsvik, M.S.; Svardal, A.; Bohov, P.; Skorve, J.; Berge, R.K. A fish protein hydrolysate alters fatty acid composition in liver and adipose tissue and increases plasma carnitine levels in a mouse model of chronic inflammation. *Lipids Health Dis.* **2013**, *12*, 143.

❖ **PERIOD IN COMPANIES – RESEARCH CENTRES – P.A.:**

The research program will be carried out in collaboration with the following subject:

Company name: Ittica Siciliana di Arturo Mannino
Registered office: Aci Catena (CT), Sicilia, Italia
Legal representative: Arturo Mannino

The aforementioned institution will host the PhD student beneficiary of the scholarship financed on the resources of the DM 351/2022 for **n. 6 months** during the PhD course.

❖ **PERIODO ALL'ESTERO:**

The research program includes a period abroad of n. 6 months at the following institution:
University of Zagreb, Department for Biology And Pathology of Fish and Bees