Functional food ingredient development from mesopelagic fish

The MEESO project is investigating the potential for functional food ingredients from mesopelagic fish.

Mesopelagic fish species include *Maurolicus muelleri* (Mueller's bristle-mouth fish), *Micromesistius poutassou* (Blue whiting) and zooplankton such as *Euphausia superba* (krill) (**Figure 1**).

The peculiar environmental conditions that exist in the ecological zone known as the 'twilight zone', including high pressure and darkness, along with the position of mesopelagic fish at the bottom of the food chain, result in a lot of diversity in their bio-composition. Mesopelagic fish are currently an underutilised resource despite the fact that they are rich in proteins, omega-3 oils, and other nutrients and bioactive ingredients (Alvheim *et al.*, 2020). They could afford processors novel opportunities to develop feed, food, and functional food ingredients and products. However, there is also a need to ensure that this resource is not overfished and that processing allows optimum use of the catch in line with UN sustainability goals and the reformed Common Fisheries Policy (CFP). Can organisms living at depths between 200 and 1,000 m in the ocean be harvested in an ecologically and economically sustainable way, or are they too vulnerable? This is the overarching question that the MEESO project, which looks at ecologically and economically sustainable mesopelagic fisheries – and in which Teagasc are research partners – seeks to answer.

Food production from sustainable fisheries is a responsible way to increase food supply without arable land, irrigation or fertilisers. Many forms of aquatic animals have smaller greenhouse gas (GHG) footprints than those that are land based, and are more efficient considering feed inputs and limitations from land or water availability. Consequently, shifting towards more 'blue' food-based diets has major potential to reduce GHG emissions. Furthermore, use of mesopelagic fish species as food ingredients has potential to improve human health. The EAT-Lancet Commission was clear about the health benefits of seafood within planetary boundaries, suggesting a reference diet consisting of 28 g of fish or shellfish per day (range 0-100 g), which is about one or two servings per week

FIGURE 1: Euphausia superba *(krill) and* Maurolicus muelleri *harvested from the twilight zone.*

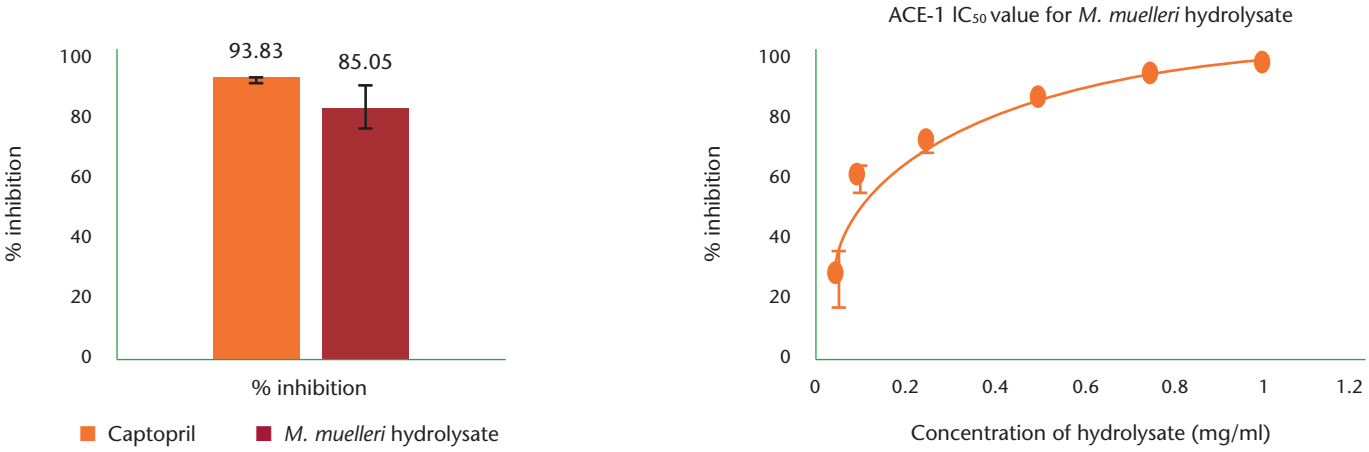

FIGURE 2: Inhibition of angiotensin-1-converting enzyme (ACE-1) by a hydrolysate of Maurolicus muelleri.

(Willett *et al.*, 2019). This recommendation is met by an increased health and environmental consciousness among consumers, which is reflected in an ongoing protein shift, i.e., the replacement of red meat by alternative protein sources.

The research

Work carried out in part by Azza Naik at Teagasc looked at protein extracts generated from mesopelagic fish including *Maurolicus muelleri*, the zooplankton *Euphausia superba* and combinations of these proteins using hydrolysis methods. Protein hydrolysates were generated by partners at Nofima and the University of Bergen using four different enzymes. Hydrolysates were characterised and assessed for their ability to inhibit enzymes important in diseases associated with metabolic syndrome. The ability of generated hydrolysates to inhibit enzymes, including angiotensin-1-converting enzyme (ACE-1; EC. 3.4.15.1) associated with blood pressure regulation, acetylcholinesterase (AChE; EC 3.1.1.7) associated with maintenance of the nervous system, and dipeptidyl peptidase IV (DPP-IV; EC 3.4.14.5) linked with development of type 2 diabetes, was determined. Hydrolysates generated contained greater than 60 % protein when analysed using the DUMAS method. A hydrolysate generated from *M. muelleri* inhibited ACE-1 by greater than 85 % when assayed at a concentration of 1 mg/ml compared to the positive control Captopril, and had an ACE-1 IC50 value of 0.1 mg/ml (**Figure 2**). Peptides were identified using a combination of high-performance liquid chromatography (HPLC) and mass spectrometry.

Conclusion

The abundant availability of fish and zooplankton (1×10^9 tonnes to 7×10^{10} tonnes) in the mesopelagic zone of the oceans is a source of novel raw materials that provides opportunities for sustainable bioprocessing. In this study, a mesopelagic *M. muelleri* hydrolysate was made with the ability to inhibit the enzyme ACE-1 – an enzyme responsible for development of high blood pressure in the renin-angiotensin-aldosterone system (RAAS). This hydrolysate could potentially have antihypertensive benefits to consumers. This work supports sustainable harvesting, while also helping to address EU health issues, including high blood pressure, through the creation of functional food ingredients.

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