

## FROM WASTE TO WELLNESS: SARDINE BY-PRODUCTS AS RICH SOURCES OF BIOACTIVE INGREDIENTS

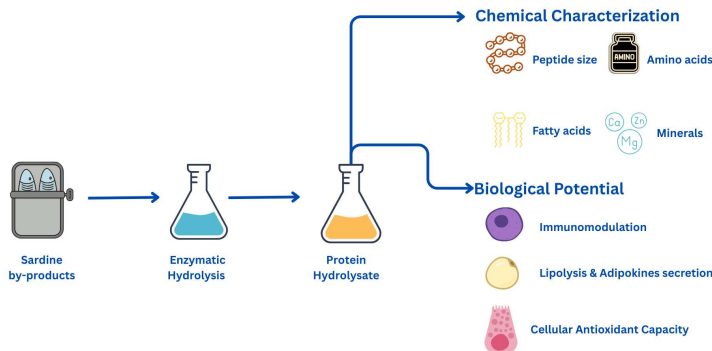
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### Abstract

The sustainable utilization of sardine by-products represents a valuable contribution to addressing global challenges in waste management and health nutrition. Sardine by-products, typically discarded or utilized as low-value inputs in animal feed and fertilizer, have demonstrated potential as a source of bioactive ingredients. This study highlights the composition and bioactive properties of sardine protein hydrolysates, derived through enzymatic hydrolysis, emphasizing their nutritional quality and biological potential. Sardine protein hydrolysates exhibit diverse molecular weight ratios and amino acid compositions that are pivotal for fulfilling established health claims. The bioactivity of these hydrolysates was assessed across various parameters, including cytotoxicity, cellular antioxidant activity, lipolysis, and immunomodulation. At a concentration of 5 mg/mL, sardine hydrolysates were found to increase intracellular reactive oxygen species (iROS) production under basal conditions, while enhancing antioxidant activity in stimulated cells. Furthermore, they modulated adipocyte metabolism by reducing lipid accumulation, decreasing leptin secretion, and increasing adiponectin secretion, demonstrating potential for metabolic health applications. The immunomodulatory effects of sardine hydrolysates were particularly noteworthy. In lipopolysaccharide (LPS)-stimulated gut cells, these hydrolysates effectively reduce pro-inflammatory cytokine secretion while increasing TNF- $\alpha$  levels under basal conditions. Such properties underline their potential role in managing inflammation-related conditions. Additionally, the mineral content of sardine by-products, particularly sodium, potassium, and phosphorus, aligns with European Food Safety Authority (EFSA) requirements for health claims. This positions sardine hydrolysates as a sustainable and nutritionally rich source of bioactive compounds that could be integrated into functional foods or nutraceutical formulations. In conclusion, the findings underscore the potential of sardine by-products as sustainable, high-value bioactive ingredients that contribute to nutrition and health while addressing environmental concerns associated with fishery by-product waste.

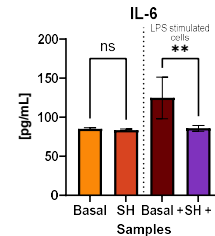
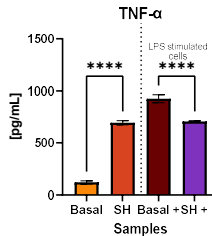
### Materials & Methods



### Results

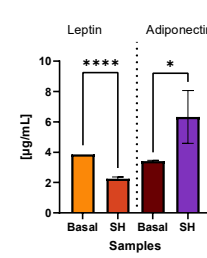
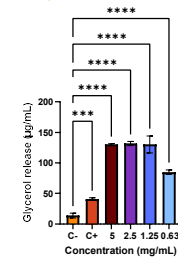
#### Biological Characterization

##### Immunomodulation



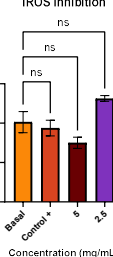
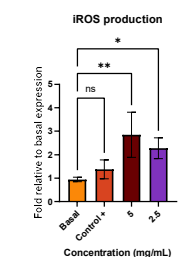
↑ TNF- $\alpha$  in basal conditions  
↓ Cytokine secretion in LPS-stimulated cells

##### Lipolysis & Adipokines Secretion



↓ Lipid accumulation  
↓ Leptin secretion  
↑ Adiponectin secretion

##### Cellular Antioxidant Capacity



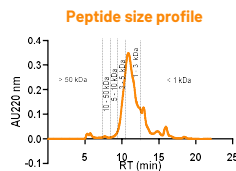
↑ iROS production in basal conditions  
= iROS production in stimulated cells

### Results

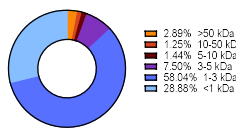
#### Chemical Characterization

##### Nutritional Composition

Protein	57.1%
Fat	24.2%
Carbohydrates	12.2%
Moisture	2.6%
Ash	4.0%

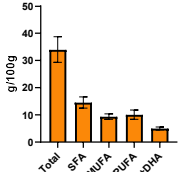


##### Peptide size ratio



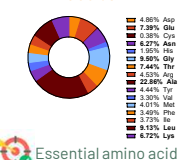
Low molecular weight peptides

##### Fatty acid profile



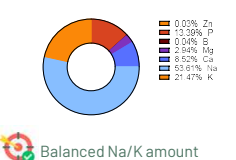
Fulfilling health claims

##### Amino acids



Essential amino acids

##### Minerals



Balanced Na/K amount

### Conclusion

This study shows that sardine by-products can be sustainably converted into protein hydrolysates with high nutritional quality, containing essential amino acids, polyunsaturated fatty acids, and bioavailable minerals. *In vitro* assays further revealed their antioxidant, metabolic, and immunomodulatory activities, highlighting their potential as multifunctional ingredients for food and nutraceutical applications.