WEFTA

MIR NATIONAL MARINE FISHERIES RESEARCH INSTITUTE

BOOK OF ABSTRACTS

53rd Conference of the West European Fish Technologists Association

13th-17th October 2025
Gdańsk, Poland

Blue Bio Opportunities for Health and Value

53rd WEFTA Conference

13th-17th October 2025, Gdańsk, Poland

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Patronat honorowy
Ministra Rolnictwa i Rozwoju Wsi
Stefana Krajewskiego

Welcome address

It is our great honour and pleasure to welcome you all to the 53rd West European Fish Technologists Association (WEFTA) Conference in Gdańsk, Poland, from October 13th to 17th, 2025. This is the second time the conference has been held in Poland. The first was the 27th WEFTA conference in 1996.

The WEFTA conference, held in various European countries, is an annual meeting of scientists involved in fish processing, applied food science, aquaculture, seafood technology, health effects of seafood consumption and consumer studies. It is not only a place to present the results of scientific results, but above all, a space to develop cooperation in joint scientific research and project implementation for both experienced scientists and students at the beginning of their scientific careers, as well as seafood industry representatives. It provides a unique opportunity to exchange knowledge, share experiences, and establish scientific and professional contacts.

The theme of WEFTA 2025 is "Blue Bio Opportunities for Health and Value", as we strongly believe that aquatic organisms still hold untapped consumer and non-consumer potential and great market value - waiting to be discovered.

The presentations and posters will be delivered in six scientific sessions in this blue biotechnology and bioeconomy sector:

I. Future & Sustainable Seafood Processing Opportunities
II. Future Raw Material Supply: Fisheries and Aquaculture Innovation
III. Next-Gen Seafood as Food: Nutrition, Health, Functionality & Sensory Quality
IV. Seafood Safety and Authenticity
V. Blue Biotechnology and Marine Bioactive Compounds
VI. Seafood Market, Consumption and Consumer Behaviour

During the conference, we will also host notable keynote speakers, whose achievements are presented in the Key Speakers section.

October is a great time to enjoy the golden Polish autumn, full of vibrant colours and soft sunshine.

Gdańsk is a city with a unique history that has had a significant impact on its modern-day landscape. For centuries, it has been a melting pot where diverse cultures, peoples, and traditions have come together to form a unique community. Gdańsk was rebuilt after the destruction during the World War and today we can admire the historical architecture, charming streets, and dynamic atmosphere. Today it is a vibrant city, full of tourists, development potential with renowned universities, research institutes and innovative companies.

I would like to express my sincere and personal thanks to the rest of the WEFTA organizing team, management of the National Marine Fisheries Research Institute, the participants, the chairpersons, the WEFTA national representatives, the members of the Scientific Committee and the WEFTA Award Selection Committee.

On behalf of the entire organizing team, we wish you five unforgettable days filled with learning, sharing experiences, enjoying social activities, and making valuable scientific connections.

Kind regards,

Olga Szulecka
Chair WEFTA 2025

Fot. P. Manasterski

Committees

Members of the Organising Committee - 53rd WEFTA

- Olga Szulecka, National Marine Fisheries Research Institute, Poland
- Tomasz Kulikowski, National Marine Fisheries Research Institute, Poland
- Jarosław Darecki, National Marine Fisheries Research Institute, Poland
- Anna Ochman, National Marine Fisheries Research Institute, Poland
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- Ingrid Underland, Chalmers, Sweden
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- Narcisa Bandarra, IPMA, Portugal
- Sanja Vidaček, University of Zagreb, Croatia
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Members of the WEFTA

- Flemming Jessen (DTU, Denmark)
- Mercedes Careche (CSIC-ICTAN, Spain)
- John Fagan (BIM, Ireland)
- Narcisa M Bandarra (IPMA, Portugal)
- Grethe Hyldig (DTU, Denmark)

Every year at the conference dinner, the WEFTA award is presented.

An annual award will be given to a WEFTA scientist who has contributed significantly and outstanding to the fields of seafood processing, seafood product development, seafood analytical methods, seafood safety, applied seafood science, seafood technology, seafood nutrition, aquaculture or consumer studies related to seafood.

The WEFTA award will be presented at the conference dinner on Wednesday 15th October 2025 by the chairperson of the Award Committee.

WEFTA 2025 Conference Programme

Monday, 13.10.2025

14:30 – 16:30	WEFTA Working Group Analytical Methods meeting Johan Robbens, ILVO, Belgium
16:30 – 19:00	National Representatives Meeting of WEFTA Olga Szulecka, NMFRI, Poland
18:30 – 20:30	Welcome Reception for participants WEFTA 2025
20:30 – 23:00	Dinner National Representatives WEFTA

Tuesday, 14.10.2025

9:00 – 9:15	Opening Ceremony of WEFTA 2025 Olga Szulecka, NMFRI, Poland
9:15 – 9:45	K01 Grethe Hyldig, DTU, Denmark (WEFTA award winner 2024)
Keynote Speach	A taste of Seafood

SESSION I. Future & Sustainable Seafood Processing Opportunities

Chairpersons	Mercedes Careche, Andreas Langdal
09:45 - 10:05	F101 Heidi A. Nilsen, Nofima AS, Norway Measuring salmon texture – developing methodology based on spectroscopy
10:05 – 10:25	F102 Jørgen Lerfall, NTNU, Norway Antimicrobial decontamination strategies for the Atlantic salmon industry - the effect of VigorOx® and hydrogen peroxide (H2O2) on fillet quality and shelf-life
10:25 – 10:45	F103 Janna Cropotova, NTNU, Norway

	Effect of ultrasound pre-treatments before enzymatic hydrolysis on quality parameters of soluble and insoluble protein fractions obtained from Atlantic mackerel side streams
10:45 – 11:15	Coffee break, poster session
CONTINUATION SESSION I. Future & Sustainable Seafood Processing Opportunities	
Chairpersons	Margrét Geirsdóttir, Adrián Honrado
11:15 – 11:35	K02 Joanna Szlinder-Richert, NMFRI, Poland
Keynote Speach	Evaluation of wastewater from Polish fish facilities: quality parameters and management approaches
11:35 – 11:55	F104 Hatairad Phetsang, Chalmers University of Technology, Sweden
	Possibilities with pH-shift processing for removal of persistent organic pollutants in whole Baltic herring
11:55 – 12:15	F105 Revilija Mozuraityte, SINTEF Ocean, Norway
	Haddock fish cakes enriched with mince of Baltic Sprat: challenges and possibilities
12:15 – 12:20	S101 Olga Szulecka, NMFRI, Poland
	Knowledge barriers and motivations for the improved utilisation of side-streams in the pelagic fish sector in Norway, Poland and France
12:20 – 12:40	F106 Ida-Johanne Jensen, NTNU, Norway
	Towards full utilization of seafood resources – opportunities and challenges
12:40 – 13:00	F107 María Gudjónsdóttir, University of Iceland, Iceland
	Multispectral imaging as a predictive tool for freshness of whole Atlantic cod: compared with sensory, chemical and microbiological analysis
13:00 – 14:00	Lunch break

CONTINUATION SESSION I. Future & Sustainable Seafood Processing Opportunities	
Chairpersons	Narcisa Bandarra, Athanasios Tsiartsafis
14:00 – 14:20	F108 Andreas Langdal, Norwegian College of Fishery Science, UiT-The Arctic University of Norway, Norway Utilisation of side-stream from blue mussel aquaculture in fish feed. Environmental footprint evaluated by life cycle assessments (LCA)
14:20 – 14:40	F109 Nina Gringer, DTU, Denmark Resource effective multi-extraction of sustainable high-value compounds from shrimp production side-stream: ReMeSS project - The final note
14:40 – 15:00	F110 Dagbjørn Skipnes, Nofima, Norway Kelp processing innovations – Norwegian perspectives
15:00 – 15:05	S102 Morten Sivertsvik, Nofima, Norway Asia–Africa BlueTech Superhighway project: Climate-Smart Technologies for Reducing Aquatic Food Waste and LossF
15:05 – 15:35	Coffee break, poster session
SESSION II. Future Raw Material Supply: Fisheries and Aquaculture Innovation	
Chairpersons	Nina Gringer, Thierry Grard
15:35 – 15:55	F201 Yusa Nakamura, Tokyo University of Marine Science and Technology, Japan Impact of seasonal variations and seawater temperature on muscle quality of farmed Pacific bluefin tuna (*Thunnus orientalis*)
15:55 – 16:15	F202 Narcisa Bandarra, IPMA, Portugal Pullet Carpet Shell Venerupis corrugata (Gmelin, 1791): innovative diets to improve farming performance
16:15 – 16:35	F203 Kaisu Honkapää, VTT Technical Research Centre of Finland, Finland Three-spined Stickleback as a Potential New Fish Oil Source
16:35 – 16:55	F204 Liam Strachan, Atlantic Technological University, Ireland

Developing a sustainable bait alternative for the common whelk, *Buccinum undatum*, pot fishery in Ireland

16:55 – 17:00 S201 Santiago Aubourg, CSIC, Spain

Common octopus (*Octopus vulgaris*) viscera as a source of healthy fatty acids: A comparative study with edible tissues

Wednesday, 15.10.2025

CONTINUATION SESSION II. Future Raw Material Supply: Fisheries and Aquaculture Innovation

Chairpersons	Ana Fuentes López, Ioannis Boziaris
8:45 – 9:05	K03 Tomasz Pyjor, MOWI, Poland
Keynote Speach	The absence of Science. Case study. Amendment of Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs
9:05 – 9:25	F205 Helena Thordis Svavarsdottir, University of Iceland, Iceland
	Evaluation of partial dry-bleeding of Atlantic salmon (*Salmo salar*) and its effects on fillet quality and stability
9:25 – 9:45	F206 Santiago Aubourg, CSIC, Spain
	Optimised low-toxicity solvents for the extraction of omega-3 fatty acids, phospholipids and tocopherols from squid (*Doriteuthis gahi*) waste
9:45 – 10:05	F207 Raúl Pérez Gálvez, University of Granada, Spain
	Development of new aquafeed formulations with higher nutritional efficacy and sustainability (PCM - 00044)
10:05 – 10:10	S202 Marjun Berbisá, Varðin Pelagic, University of the Faroe Islands, Faroe Islands
	Assessing Pelagic Fish Biomass Through ddPCR Analysis of eDNA and eRNA

10:10 – 10:40	Coffee break, poster sessions

SESSION III. Next-Gen Seafood as Food: Nutrition, Health, Functionality & Sensory Quality

Chairpersons	Ingrid Undeland, Matteo Orlando

10:40 – 11:00 F301 Margrethe Esaiassen, Nofima, Norway

Biochemical and quality changes in Pink salmon (*Oncorhynchus gorbuscha*) during sexual maturation: Implications for food use

11:00 – 11:20 F302 Narcisa Bandarra, IPMA, Portugal

Seafood Intake and Impact on the Omega-3 Index

11:20 – 11:40 F303 Revilija Mozuraityte, SINTEF Ocean, Norway

Oxidation of herring oil and effect of antioxidants

11:40 – 12:00 F304 Rebecca Strand, Chalmers University of Technology, Sweden

Novel insights into herring (*Clupea harengus*) hemoglobins and their ability to promote heme-mediated lipid oxidation

12:00 – 12:20 F305 Anna-Liisa Välimaa, Luke, Finland

Fermented fish products from Baltic herring (*Clupea harengus membras*)

12:20 – 12:40 F306 Mariusz Szymczak, WPUT in Szczecin, Poland

Effect of salt type on the ripening of marinades from Baltic herring fillets

12:40 – 12:45 S301 Feijian Liu, Chalmers University of Technology, Sweden

Innovative processing strategies for small-sized Baltic herring and comprehensive nutritional profiling of derived cuts

12:45 – 13:45	Lunch break

CONTINUATION SESSION III. Next-Gen Seafood as Food: Nutrition, Health, Functionality & Sensory Quality

Chairpersons	Revilija Mozuraityte, John Fagan

13:45 – 14:05 F307 Carlos Cardoso, IPMA, Portugal

	Maximizing omega-3 health benefits: the gilthead seabream case-study as a reflection on the challenge of harmonizing sustainability, affordability, quality, safety, and health
14:05 – 14:25	F308 Margrét Geirsdóttir, Matís, Iceland Colour, health, and hurdles: unlocking spirulina's potential in functional beverages
14:25 – 14:45	S302 Johan Robbens, ILVO, Belgium Turning seaweed into functional food & feed ingredients
14:45 – 14:50	S303 Rufa Mendez, Chalmers University of Technology, Sweden Functional seaweed hydrolysates for food application: an in silico prospecting approach
14:50 – 15:10	F309 Grzegorz Tokarczyk, WPUT in Szczecin, Poland The use of farmed common carp (*Cyprinus carpio*) meat for the production of innovative fish snacks
15:10 – 15:40	Coffee break, poster session
CONTINUATION SESSION III. Next-Gen Seafood as Food: Nutrition, Health, Functionality & Sensory Quality	
Chairpersons	Klara Helgesson, Santiago Aubourg
15:40 – 16:00	F310 Sławomir Michniewski, University of Leicester, United Kingdom Development of a phage cocktail for the shelf-life extension of *Nephrops novegicus*
16:00 – 16:20	F311 Ingrid Undeland, Chalmers University of Technology, Sweden A new approach to extract multifunctional seaweed protein ingredients rich in vitamin B12 and polyunsaturated fatty acids
16:20 – 16:40	F312 Ida-Johanne Jensen, NTNU, Norway Quality of pelagic side-streams
16:40 – 17:00	F313 Cláudia Afonso, IPMA, Portugal Blue resources for functional foods: innovation and evidence-based insights on the valorization of aquatic biodiversity for health and well-being
17:00 – 17:05	S304 Adrián Honrado, Universidad de Zaragoza-CITA, Spain

Improving the nutritional and sensory quality of baguette bread with functional ingredients from fish by-products hydrolysates

19:00-00:00 – Gala Dinner "Piwnica Rajców" in Gdańsk

Thursday, 16.10.2025

SESSION IV. Seafood Safety and Authenticity

Chairpersons	Janna Cropotova, Johan Robbens
9:00 – 9:20	F401 Anita Nordeng Jakobsen, NTNU, Norway
	Biocontrol of *Listeria monocytogenes* in Ready-to-Eat Atlantic salmon using lactic acid bacteria: safety assessment and antilisterial effects
9:20 – 9:40	F402 Ioannis Boziaris, University of Thessaly, Greece
	Seafood spoilage/freshness determination: from the lab analysis to intelligent management systems
09:40 – 10:00	F403 Athanasios Tsiartsafis, University of Thessaly, Greece
	Antibiotic-resistant versus antibiotic-susceptible pathogens in mussels and their farming water
10:00 – 10:20	F404 Lorenzo Chinellato, DTU, Denmark
	Seasonal variation in the microbial communities of the Green Crab
10:20 – 10:40	F405 Agnieszka Nona-Mołdawa, bioMerieux, Poland
	Detect, control, save — innovative food safety technologies for the fish industry
10:40 – 10:45	S401 Matthew Ford, University of Leicester, United Kingdom
	Endolysins as a therapy for prevention of salmon associated pasteurellosis

10:45 – 11:15	Coffee break, poster session

CONTINUATION SESSION IV. Seafood Safety and Authenticity

Chairpersons	Heidi A. Nilsen, Lorenzo Chinellato

11:15 – 11:35 F406 Marina Usieto, ICTAN-CSIC, Spain

Beyond 60 °C: validating thermal safety against anisakis in traditional cooking

11:35 – 11:55 F407 Sónia Pedro, IPMA, Portugal

Management of Portuguese shellfish mainland production areas classified in 2024

11:55 – 12:00 S402 Ana Fuentes López, Universitat Politècnica de València, Spain

Effect of carvacrol on histamine production in canned tuna inoculated with *R. planticola*

12:00 – 12:05 S403 Narcisa Bandarra, IPMA, Portugal

Total an inorganic arsenic in seafood products commercialised in Portugal

12:05 – 12:10 S404 Ute Schröder, Max Rubner-Institut, Germany

Fish products in the e-commerce: Quality and labelling

12:10 – 12:15 S405 Evangelia A. Karamani, University of Thessaly, Greece

HRM as a practical and effective tool for the rapid source tracking of foodborne pathogens along the whole fish production chain in aquaculture

SESSION V. Blue Biotechnology and Marine Bioactive Compounds

12:15 – 12:35 F501 Morten Sivertsvik, Nofima AS, Norway

A novel method of pre-treating microalgae biomass, resistant to cell disruption, with Plasma-Activated Water and Pulsed Electric Field for improving the accessibility of cellular compounds therefrom

12:35 – 12:55 F502 Carlos Cardoso IPMA, Portugal

The Vermetid gastropod *Vermetus triquetrus*: an underexplored marine resource with biomass fractions rich in polyphenols and displaying high antioxidant activity

12:55 – 13:00 S501 Narcisa Bandarra, IPMA, Portugal

Lipidomic profiling and anti-inflammatory activity study of a poorly known marine organism, a Vermetid mollusk in the Portuguese shore

13:00 – 14:00	Lunch break

CONTINUATION SESSION V. Blue Biotechnology and Marine Bioactive Compounds

Chairpersons	Ida-Johanne Jensen, Sławomir Michniewski
14:00 – 14:20	F503 Maria Hayes, Teagasc Food Research Centre, Ireland

Identification of bioactive peptides with potential for use in functional foods and feeds from mesopelagic fish & underutilised marine species.

14:20 – 14:25	S502 Małgorzata Malesa-Ciećwierz, NMFRI, Poland

Protein hydrolysates derived from side streams generated by Polish fish processing plants

14:25 – 14:45	F505 Carlos Cardoso, IPMA, Portugal

Overcoming extraction hurdles and assessing biological activity in a major invasive seaweed species in Europe, *Rugulopteryx okamurae*

14:45 – 14:50	S503 Marina Stramarkou, Teagasc, Ireland

Sequential extraction of polysaccharides and proteins from the invasive macroalga *Sargassum muticum*

14:50 – 15:30	Coffee break, poster session

SESSION VI. Seafood Market, Consumption and Consumer Behaviour

Chairpersons	Sanja Vidaček Filipec, Raúl Pérez-Gálvez
15:30 – 15:50	F601 Tomasz Kulikowski, NMFRI, Poland

African catfish in Central and Eastern Europe: consumer awareness, purchase experience, and market potential

15:50 – 16:10	F602 Morten Heide, Nofima, Norway

Barriers and opportunities for the successful market introduction of novel algae-based products

16:10 – 16:15	S601 Sónia Pedro, IPMA, Portugal

Species monitored in Portuguese shellfish coastal production areas during the last decade

16:15 – 16:20 S602 Matteo Orlando, University of Florence, Italy

K-EAT: Sharing scientific knowledge to build up responsible and aware consumers of tomorrow

16:20 – 16:25 S603 Tomasz Kulikowski, NMFRI, Poland

Sales potential of carp (*Cyprinus carpio*) in Poland through short food supply chains: consumer research insights

Closing ceremony

16:25 – 16:40 Report WEFTA national representative meeting and WEFTA analytical working group

Olga Szulecka, NNFRI, Poland and Johan Robbens, ILVO, Belgium

16:40 – 16:50 WEFTA 2026 Announcement

16:50 – 17:00 Closing WEFTA 2025 – Olga Szulecka NMFRI, Poland

17:00 – 18:30 Goodbye Reception

Friday, 17.10.2025

8:00 – 17:30 Study Tour - Aquaculture & Processing Tour
8:00 – 17:00 Regional Tour to Malbork

POSTERS

SESSION I. Future & Sustainable Seafood Processing Opportunities

P01 Tibor Jančí, University of Zagreb, Croatia
Functional edible films for fish preservation: Application of chitosan and gelatin based coatings with plant extracts

P02 Klara Helgesson, Chalmers University of Technology, Sweden

Cultivation of seaweeds with food process waters for sustainable protein production

P03 Andrew Couper, University of Lincoln, United Kingdom
University of Lincoln seafood engagement update

SESSION II. Future Raw Material Supply: Fisheries and Aquaculture Innovation

P04 Santiago Aubourg, CSIC, Spain

Optimisation of enzymatic acidolysis of EPA+DHA from rainbow trout and tocopherols from maqui seed oil under supercritical CO_2 conditions

P05 Santiago Aubourg, CSIC, Spain

Comparative proximate, phospholipid and fatty acid values in edible and non-edible tissues of carp (Cyprinus carpio) cultivated in Madagascar

P06 Santiago Aubourg, CSIC, Spain

Biorefinery of bioactive compounds from cochayuyo (*Durvillaea incurvata*) through UAE and PLE

P07 Raúl Pérez Gálvez, University of Granada, Spain

Valorisation of tuna head by-products to obtain peptide fractions with in vitro antioxidant activity for aquafeeds

P08 Margrethe Esaiassen, Nofima, Norway
Farmed Atlantic cod in Norway: Status and challenges

SESSION IV. Seafood Safety and Authenticity

P09 Dimitrios A. Anagnostopoulos, University of Thessaly, Greece

Antibiotic resistance and biofilm formation mechanisms correlated with the dominant microbiota along the whole fish production chain of aquaculture

P10 Despoina Kokioumi, University of Thessaly, Greece

Antibiotic resistance of Enterococcus spp. along the whole fish production chain of aquaculture in Greece

P11 Stavroula Letsiou, University of Thessaly, Greece

Presence and distribution of Antibiotic-Resistant Bacteria in various pre-fattening and processing plant spots of aquaculture production system and fish via advanced statistical analysis

P12 Adrián Honrado, Universidad de Zaragoza-CITA, Spain

Sensitive ELISA and lateral flow immunoassay to detect fish traces in processed food

P13 Ana Fuentes López, Universitat Politècnica de València, Spain

Effect of essential oils compounds against histamine-producing bacteria

P14 Isabel Fernández Segovia, Universitat Politècnica de València, Spain
Development of photonic multi-sensing system for histamine analysis in fish products

SESSION V. Blue Biotechnology and Marine Bioactive Compounds

P15 Ying Wang, The Norwegian College of Fishery Science, UiT-The Arctic University of Norway

Bioactivity of Calanus finmarchicus during in vitro gastrointestinal digestion

P16 Grzegorz Tokarczyk, WPUT in Szczecin, Poland
Fish meat hydrolysates as bioactive peptides source

P17 Samantha DRUELLE, University of Lille, France

Green extraction and separation processes for seaweed biorefineries

SESSION VI. Seafood Market, Consumption and Consumer Behaviour

P18 Sanja Vidaček Filipec, University of Zagreb, Croatia

Consumer response to the introduction of a Mediterranean-style fish dish in Croatian university canteens

P19 Giuliana Parisi, University of Florence, Italy

Visual storytelling for science: a co-created comic on aquaculture

P20 Giuliana Parisi, University of Florence, Italy

The shark meat market: data trends and critical issues in the Italian context

P21 Isabel Fernández Segovia, Universitat Politècnica de València, Spain

Fish by-products as food ingredients: What do consumers think?

KEYNOTES

Grethe Hyldig Ph.D.

A taste of seafood

Institution: DTU Food, Denmark

Grethe Hyldig, is Senior Researcher in Sensory Science and the leader of the sensory group at the National Food Institute, in the Research Group for Bioactives – Analysis and Application at the Technical University of Denmark.

In 1996 she came to the National Institute of Aquatic Resources (DTU Aqua) where she established a group that worked with sustainable and innovative use of traditional and alternative fish species, and the preservation of quality from catch to consumer, and has made sensory analysis an important part of this work. The sensory group, she has formed and supervised, has an extensive knowledge and experience within the area of sensory quality of seafood. The group works with consumer preferences and sensory quality. important parts of the work are development of methods for evaluating eating quality and shelf life for predicting quality and shelf life under known storage conditions. Grethe is one of the core researchers in the development and validation of the Quality Index Method (QIM) schemes internationally. She gives national and international QIM courses, both for implementation and use of QIM and for developing new schemes at all academic levels. The work includes acceptance and preference tests, combined with focus groups and surveys to describe consumers' perception of quality, information requests and motive for the purchases. When the group moved to DTU Food in 2010 the work was extended to include seaweed, meat, vegetables, beer and other commodities.

Grethe has also been an important participant in the Establishment of a Danish sensory research network – SensNet - that was founded in a desire to develop and expand the sensory research, education and innovation at the three food Universities, namely the University of Copenhagen, Aarhus University and the Danish Technical University at a national and international level. The work of SensNet

is now continued in the Danish Sensory Society under the Association of Danish Engineers. In 2014 she was the head of the organising committee of the Sixth European Conference on Sensory and Consumer Research in Copenhagen. She has also been the president of the Nordic-Baltic Committee on Food Analysis and is still a member of the sensory group.

The eating quality plays a very important role both when focus is on health and value of “blue” ingredients and seafood. Through many projects studies have investigated the influence of different treatments, processes and natural changes on the sensory quality of seafood and ingredients processed from the production of seafood. This presentation will summarize the sensory knowledge obtained through the past 20+ years seafood projects.

Dr. Eng. Joanna Szlinder-Richert, Professor of NMFRI

Evaluation of wastewater from Polish fish facilities: quality parameters and management approaches

Institution: National Marine Fisheries Research Institute, Poland

Dr. Eng. Joanna Szlinder-Richert graduated from the Faculty of Chemistry at the Technical University of Gdansk in 1997. After graduation, she has started her research on the activity of antifungal antibiotics - derivatives of amphotericin B, and in 2002 she completed her doctorate.

In 2003, she joined the National Marine Fisheries Research (NMFRI) and her further professional career has been associated with fishery, marine environmental research, and seafood processing technology. She holds her habilitation in discipline of oceanology since 2014.

She initially worked at the NMFRI at the position of a specialist, and this allowed her to acquire high practical skills in analytical chemistry, especially chromatographic techniques, which she later used in her scientific work. In 2009 she obtained the scientific position in the Department of Food and Environmental Chemistry and in the period between 2014 and 2018 she acted as the head of the Department. Currently, she holds the position of the NMFRI Deputy Director for Scientific Matters, coordinating research activities aimed at supporting implementation of the EU Common Fisheries Policy (CFP), which calls for ensuring economically, environmentally and socially sustainable management of fisheries resources. Since the CFP covers all aspects of fishing- from fishing grounds to the consumer, it requires multidisciplinary research related to stock biomass assessment, the impact of environmental factors on ichthyofauna and environmental impact of fisheries, as well as constantly improving processing technologies and identifying the best strategies for the valorisation of byproducts.

Joanna Szlinder-Richert throughout her scientific career has been particularly involved in several research topics relevant to marine environment and its exploitation.

The scope of her activity covers a wide variety of topics, like the presence of contaminants in marine ecosystems and its impact on the quality of fish habitat and seafood, research on health-promoting qualities of seafood and aquaculture products, waste management in fish processing plants. The fatty acid research she has been conducting, is aimed not only at assessing the health impact of food, but it is also applicable to the study of trophic relationships in marine ecosystems. Her expertise concerning the presence and fate of contaminants in the marine environment allowed her to be involved in the work related to the national implementation of the Marine Framework Directive which is being carried out at the NMFRI for the Chief Inspectorate of Environmental Protection. In addition, she actively participates in the work of the Inter-Ministerial Panel on Hazardous Materials Deposited in Polish Maritime Areas, as a representative of the Minister of Agriculture and Rural Development.

Recently, she has initiated research at the Institute into the use of near-infrared spectroscopy, as a green technology, that may have wide applications in both fisheries management and food quality assessment.

In recent years she has been involved in several research projects aimed at applying innovative solutions in fish processing and promotion of production in Recirculating Aquaculture Systems as environmentally sustainable method of addressing the market demand for fish, and provided training for representatives of the fish industry, administration and veterinary authorities.

During the WEFTA 2025 conference, she will briefly present the Polish fish processing industry and the milestones that caused its development and led to the state we are witnessing today. She will also present results of the study conducted at the NMFRI about the quantity and quality of wastewater generated during fish processing in Polish plants depending on the production profile. The data on load of nutrients and the effectiveness of the mechanical-chemical pretreatment implemented at studied facilities will be discussed in the context of environmental issues and the possibility of recovery and reuse of valuably components.

Tomasz Pyjor, Quality Director

The absence of Science. Case study. Amendment of Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs

Institution: Mowi Poland S.A., Poland

Tomasz Pyjor graduated Inland Fishery at the University of Agriculture and Technology, Olsztyn, Poland. Since then he has worked in fish processing, first small scale and local, then 10 years in a factory which had so called "licence to export to the EU" (before Poland joined the EU) and then 20 years in the biggest salmon processing plant - Mowi Poland.

He successfully applied for the first IFS certificate in fish processing in Poland.

Factory he works for processes 100 k tons of raw material processing it into various (smoked, raw, marinated) RTE and RTC products. He started as Production Manager and for the last 6 years as Quality Director of Mowi CE, managing quality in 3 factories, subcontracted factories, and Sales Business Units.

Every second smoked salmon in Germany and 25% of all smoked salmon in EU comes from Mowi Poland. Factories have excellent Listeria results, 30 times better than the rest of industry (based on RASFF reports).

The large scale of processing, numerous audits, demanding customers, retailers and markets (US included) challenges his daily work. Listeria program which he conducts, committed and experienced team, in house lab are the key success components.

He has deep knowledge about industry thanks to the fact that he was Vice-President of European Salmon Smokers Association (2014–2016) and he has been board member (since 2019) and Vice-President (since 2023) of PSPR (Polish Association of Fish Processors). On behalf of PSPR, he participated in the work of the AIPCE Working Group on Food Law and consults Food Law with Polish authorities.

He also conducted substantive consultations of "Code of Good Production Practices in Fish Processing" (Szulecka O. (ed.), 2020), published by MIR-PIB.

Tomasz Pyjor will present the issue of changes in legal regulations in particular Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. The case will show that during law amendment experts were not seeking support from National Institutes which resulted in lack of tools to mitigate the consequences of the amendments of Commission Regulation (EC) No 2073/2005 implementation.

ABSTRACTS

53rd WEFTA Conference
13th-17th October 2025, Gdańsk, Poland
Blue Bio Opportunities for Health and Value

Measuring salmon texture – developing methodology based on spectroscopy

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Abstract

Background
Texture is a key quality parameter in salmon fillets, influencing both consumer satisfaction and industrial processing efficiency. Variability in texture, resulting from biological, environmental, and handling factors, can lead to customer complaints and financial losses for producers. The aquaculture industry has long sought non-invasive, scalable tools for assessing fillet texture during production and processing.

Aim of research
The aim of this research was to investigate the potential of spectroscopy-based techniques, specifically hyperspectral imaging (HSI) and magnetic resonance imaging (MRI), to measure and predict texture properties in salmon fillets.

Material and methods
Several independent experiments were conducted to capture a broad range of natural variability in salmon fillet texture. Fresh salmon was purchased from Norwegian producers, representing a span in the region of production as well as in production regime and season. The experiments involved: Instrumental texture analysis using tensile and puncture tests at standardized locations on the fillets; sensory evaluation by trained panelists, assessing attributes such as firmness and gaping; hyperspectral imaging (400-1000 nm) and MRI scanning performed on the same fillets. The measurements were conducted both on the day of filleting and later after storage on ice, to assess temporal changes in texture.

The resulting dataset was used to train and validate artificial neural network models for predicting both instrumental and sensory texture scores from hyperspectral data. Model performance was evaluated within and across experiments to assess generalizability.

Results and discussion

Texture was found to be spatially heterogeneous, with the Norwegian Quality Cut (NQC) area consistently firmer than the loin. Ice storage generally led to texture softening. Neural network models trained on hyperspectral data showed promising success in predicting texture using data drawn from the same experimental sets though performed less effectively on independent experiment datasets, indicating limited generalizability. Some models demonstrated potential for coarse classification (e.g., firm vs. soft), but not for fine-grained quality grading.

Conclusion

Spectroscopy-based methods show promise for non-invasive texture assessment in salmon fillets, particularly for broad classification tasks. The high variability in texture arises from complex interactions among biological factors, environmental conditions, and pre- and post- harvest handling, complicating the development of reliable texture assessment tools and highlighting the need for further studies to improve model generalization. Future work should focus on large-scale industrial data collection, alternative spectral ranges, and multimodal data integration to enhance predictive performance.

Antimicrobial decontamination strategies for the Atlantic salmon industry – the effect of VigorOx® and hydrogen peroxide (H2O2) on fillet quality and shelf-life

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Abstract

Aim of research:

The present study aimed to assess the potential of VigorOx® and hydrogen peroxide (H2O2) as non-thermal antimicrobial decontamination strategies for maintaining quality and extending the shelf life of Atlantic salmon fillets. Additionally, the concept can be used to target Listeria monocytogenes, a food safety issue in the Atlantic salmon industry

Materials and methods:

In the present study, vacuum-packaged Salmon back loins (approximately 400 g × 8) were purchased from a Norwegian producer and transported to NTNU. When produced, the back loins were vacuum-packaged within 2 hours after killing and stored at < 2 °C during transport and until processing at NTNU six days later.

The back loins were further cut into samples (approximately 30 g) and randomly divided into five experimental groups (n = 21 × 5). The experimental design was set up to evaluate the effect of VigorOx® (100 and 200 ppm) and H2O2 (1% and 2%) on maintaining the fillet quality and improving the shelf-life. The solvent used was seawater, and the control group was treated with seawater only. The pH of the processing water was measured using a portable pH meter (Hach HQ40d Multi-Portable Meter, Hach, USA) equipped with a pH electrode (Hach Intellical™ PHC108, Hach, CO, USA).

The treatment time was fixed to 3 minutes for all groups, and all treatments were performed with a sample solvent ratio of approximately 1:4. Before the treatment started, five samples were selected to represent the baseline and analyzed according to the evaluation criteria selected. After the treatments, all samples, except for those allocated to be the baseline (n = 5), and the day 0 samples (n = 3 × 5), were packaged (25mbar) in 20-µm polyamide (PA)/70-µm polyethylene (PE) bags (160 × 200 mm,

oxygen transmission rate (OTR) 50 cm3/m2 × 24 h × bar at 23 °C, Star-Pack Productive, Boissy-l'Aillerie, France with a Webomatic Supermax-C vacuum machine (Webomatic, Bochum, Germany) and stored at 4 °C until sampling on days 3, 6, 9, 12, 15, and 18.
The effects of the different decontamination strategies were followed by analysing the total mesophilic plate count (APC) and H2S-producing bacteria (HSPB) on Lyngby's Iron agar (Oxoid) supplemented with 0.4% L-cysteine (NMKL, 2006), the K- and H-value (the degradation of ATP) (Ulleberg et al., 2023), and colourimetric parameters (CIE, 1994) measured on a Videometer Lab multispectral imaging system (Videometer AS, Denmark).

Results and discussion:
The pH of the processing water was found to be affected by the decontamination agent used, where VigorOx® gave a lower pH compared to H2O2 (on average: 5.40 and 6.82, respectively). However, no significant effect of increased agent concentration was observed, resulting in approximately the same pH for VigorOx® 100 ppm and 200 ppm (pH 5.44 and 5.36, respectively) and H2O2 1% and 2% (pH 6.84 and 6.80, respectively). The pH of the control was 7.21.
The antibacterial effect of both VigorOx® and H2O2 was found to be significant, resulting in the lowest APC within the samples treated with VigorOx® 200 ppm (APC of 5.2 ± 0.22 log CFU/g), on day 19. The effect of H2O2 was most pronounced until day 7, when both groups had approximately 1 log unit lower APC than the control group. From day 10 and throughout the storage trial, the effects of H2O2 1% and 2% were minor, resulting in increased bacterial growth, which ended at APC levels of 7.1 ± 0.13 and 7.4 ± 0.21 log CFU/g, respectively, by day 19. The pattern regarding HSPB was not that clear, with more sporadic bacterial growth. However, for the groups VigorOx® 200 ppm and H2O2 2%, no growth of HSPB was observed after day 10 and throughout the storage trial. Based on the results, it appears that both decontamination agents have a more pronounced decontamination effect on the HSPB compared to the APC.
Moreover, the concentration of hypoxanthine (Hx) and the H-value correlated significantly with the APC, indicating improved freshness and fillet shelf life after the decontamination (data will be presented in detail at the conference).
No clear pattern regarding the development of colorimetric properties (CIE Lab) was found either during the treatment itself or throughout the storage trial. Minor main effects were observed between groups and days; however, they were small and had no practical importance for the visual performance of the salmon fillets.

Conclusion:
In conclusion, both VigorOx® and H2O2 were found to alter bacterial growth and improve fillet freshness and shelf life of Atlantic salmon (Salmo salar L.) fillets. Moreover, the treatments did not negatively affect visual perception, as measured by CIE Lab, during the fillet's shelf life, indicating a potential application of the concept, such as against the pathogenic L. monocytogenes, a significant food safety issue for the salmon industry.

References:

CIE. (1994). Survey of reference materials for testing the performance of spectrophotometers and colorimeters.
NMKL. (2006). Aerobic count and specific spoilage organisms in fish and fish products (Nordic committee on food analysis, method no. 184, Issue.
Ulleberg, D., Sletten, I. B., Jakobsen, A. N., Svenning, J. B., & Lerfall, J. (2023). Co-products from the Atlantic salmon filleting industry – Their properties, stability and potential as human food ingredients. LWT, 180, 114673. https://doi.org/https://doi.org/10.1016/j.lwt.2023.114673

Effect of ultrasound pre-treatments before enzymatic hydrolysis on quality parameters of soluble and insoluble protein fractions obtained from Atlantic mackerel side streams

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Abstract

Fish side streams obtained after processing of fish, represent a valuable source of essential nutrients such as lipids rich omega-3 polyunsaturated fatty acids, indispensable amino acids, vitamins and minerals. To recover valuable lipid and protein compounds, enzymatic hydrolysis is normally used, during which the fish raw material is divided into lipid and two protein fractions: soluble (fish protein hydrolysate - FPH) and insoluble (sediments). To improve the quality of the soluble and insoluble protein fractions, advanced non-thermal technologies such as ultrasound (US), can be used as pre-treatments before enzymatic hydrolysis.

The present study aims at investigating the effect of US pre-treatment before enzymatic hydrolysis on quality parameters of both soluble and insoluble protein fractions obtained from Atlantic mackerel side streams. In total, four insoluble fractions were obtained: control without US-treatment and US-treated samples at 300 W, 450 W and 600 W at 20 kHz before enzymatic hydrolysis.

The results demonstrated that US pre-treatment produced FPHs with better quality characteristics compared to the control. Specifically, FPHs from US-treated mackerel mince were lighter, less reddish, and contained a lower proportion of hydrophobic free amino acids, which are associated with bitterness. Additionally, FPH samples obtained from US-treated fish mince exhibited higher protein solubility and degree of hydrolysis than the control (untreated). In addition, US-treatment resulted in significant ($p<0,05$) increase in total protein content in insoluble protein fraction US-treated at 300 W. However, it was a significant increase in salt-soluble proteins in the sediment samples ultrasonicated at 450 W and 600 W, accompanied by a significant increase in water-soluble proteins in the sample 600 W compared

to control. This tendency can be explained by breaking down hydrogen and hydrophobic bonds of both types of proteins due to stronger cavitation effect at higher US intensities, leading to the exposure of hydrophilic groups of amino acid residues. This resulted in protein oxidation of the insoluble protein fractions, by reducing total thiols in all US-treated samples compared to control due to unfolding of proteins and breakage of disulfide bonds. However, in regard to lipid oxidation in insoluble protein fractions containing phospholipids, there was no significant differences in secondary lipid oxidation products expressed between the samples.

From the nutritional perspective, the nutritional indexes of lipid quality AI (atherogenicity index), TI (thrombogenicity index), and HH (hypocholesterolemic fatty acid ratio) were favorable for all insoluble protein fractions. However, US-treatment significantly improved hypocholesterolemic profile of US-treated insoluble protein fractions compared to control, increasing their beneficial effect to healthy cholesterol metabolism.

Regarding color parameters, no significant differences in lightness (L*-value), redness (a*-value) and yellowness (b*-value) between control and insoluble protein fractions after US-treatment at 300 W and 450 W, were found.

Thus, it was revealed that US-treatment of Atlantic mackerel side streams before enzymatic hydrolysis can significantly improve physicochemical and nutritional quality of both soluble and insoluble protein fractions.

Possibilities with pH-shift processing for removal of persistent organic pollutants in whole Baltic herring

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Abstract

Herring (Clupea harengus) is considered one of the most valuable European animal-based food protein sources in terms of its high nutritional properties and low environmental impact. Despite its potential, the use of Baltic herring in food production remains limited, and instead, >90% is landed directly for feed production. A contributing reason for this is elevated levels of environmental contamination such as dioxins, PCBs, and PFASs in catches from certain regions. Our previous work addressed part of this issue by investigating dioxin and PCBs levels in gutted Baltic herring as well as their removal during pH-shift-based production of a protein-enriched ingredient (Marmon, Liljelind, & Undeland, 2009). In the present study, we expanded the scope to whole Baltic herring and re-assessed levels of dioxins and PCBs pre- and post-processing, while also introducing PFASs-analyses. The latter are currently among the most pressing global food safety concerns. Preliminary results revealed that dioxin and PCB-levels in the Baltic herring raw material used were below EU regulatory limits, and it was further confirmed that during pH-shift processing, these contaminants primarily partitioned into the fat layer emerging in the first process step, consistent with their lipophilic nature. During alkali-aided pH-shift processing, the total removal of dioxins, dioxin like (dl) PCBs and non-dioxin like (ndl) PCBs was 44, 63 and 59%, respectively, while in the acid process version, 15, 48, and 34%, respectively, were removed. Among the PFASs analyzed; PFOS, PFOA, PFNA, and PFHxS, only PFOS was below EFSA limits in the herring raw material, while the others, and their combined total, exceeded regulatory thresholds. No reduction in total PFAS levels was observed under either acidic or alkaline pH-shift processing, although differences in PFASs retention were found between the two process versions. Our results align with the more amphiphilic and aqueous nature of these molecules compared to dioxins and PCB. The present findings highlight the potential of pH-shift processing for partial decontamination of Baltic herring, but also calls for further process tuning to better tackle reductions in PFAS-levels. For both the fisheries and food industry, our study paves the way for innovative, scalable solutions to fulfil national and EU-strategies which call for increased food production from the large catches of Baltic herring. By ensuring compliance with food safety regulations, raised food

preparedness is facilitated while at the same time the need for sustainably sourced, nutritious and affordable seafood products is met.

Reference: Marmon, S. K., Liljelind, P., & Undeland, I. (2009). Removal of lipids, dioxins, and polychlorinated biphenyls during production of protein isolates from Baltic herring (Clupea harengus) using pH-shift processes. Journal of Agricultural and Food Chemistry, 57(17), 7819-7825.

Haddock fish cakes enriched with mince of Baltic Sprat: challenges and possibilities

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Abstract

The growth of the global population leads to increased demand for sustainable food sources. Marine ecosystems, particularly low-trophic species, represent a largely underutilized resource with considerable potential for contributing to global food security. However, the effective utilization of these resources requires the development of novel processing techniques, refinement methods, and innovative product applications tailored to human consumption.
The IMPRESS project aims to address key sustainability challenges by advancing technologies and methodologies for the responsible valorization of underutilized marine and freshwater biomass. Through an interdisciplinary approach, IMPRESS seeks to enable the transition toward more sustainable and diversified aquatic food systems. In the project SINTEF Ocean focuses on product development related to new and underutilized species. Sprat (Sprattus sprattus) is a small oily fish which is a good source of vitamins, minerals, and proteins. Sprat is utilized to some extend for human consumption in Eastern European and Scandinavian countries but up to 90% of sprat catch is used for feed ingredient production. This study evaluated possibilities to enrich traditional haddock fish cakes with mince of Baltic Sprat to encourage greater use of sprat for human consumption. Replacing 25% of haddock with mince of sprat increased the lipid amount in the final fish cake. The omega-3 fatty acid amount increased from 120 mg/100g haddock fish cake to 700 mg/100g fish cake enriched fish mince of sprat. Addition of sprat in fish cake reduce lightness of fish cake and the texture became softer. Addition of potato flakes in the fish cakes enriched with sprat, helped to increase lightness and firmness of cakes to some extent. However, sensory evaluation indicated the need of some taste improvement.

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Knowledge barriers and motivations for the improved utilisation of side-streams in the pelagic fish sector in Norway, Poland and France

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Abstract

Introduction

Side-streams from pelagic fish (such as herring and mackerel) processing, including heads, guts, backbones, bellyflaps, fins, skins and scales, are valuable raw materials rich in proteins, omega-3 fatty acids, vitamins, and essential elements. Currently, these side-streams are primarily used for fishmeal, fish oil, and pet food, yet they hold potential for broader applications within the food industry. However, enabling such a transition would require new technologies, organizational changes, targeted investments, and skilled personnel.

The study aimed to investigate knowledge barriers and motivations for the improved utilisation of fish side-streams for food in the pelagic fish sectors of Norway, Poland, and France.

Materials and methods

The study focused on stakeholders within the pelagic fish supply chain, especially processing companies, in Norway, Poland and France. A mixed-methods approach was applied, combining a quantitative Computer-Assisted Web Interviewing (CAWI) survey and qualitative in-depth interviews (IDIs). The CAWI survey was conducted in Q4 2024 and involved 37 (micro, small, medium and large) companies: 16 in Poland, 11 in France and 10 in Norway. Knowledge barriers and motivators were rated on a 5-point scale. The qualitative phase comprised 11 IDIs conducted between Q4 2024 and Q1 2025: four in

Norway, four in Poland and three in France. These interviews offered deeper insight into operational challenges and strategic motivations regarding side-stream utilisation.

Results

Findings from the CAWI survey in the fish pelagic sector highlighted different leading knowledge barriers across the three countries: in Norway, the most significant knowledge barrier was related to tax incentives for implementing new solutions (3.8 ± 1.2), in Poland - to the production issues, specifically the lack of knowledge on how to produce a new products with nutrients recovered from side-streams (3.7 ± 1.1) and in France the most significant knowledge barrier was connected to the lack of knowledge about legal aspects of side-stream ingredients application for food purposes (4.2 ± 0.9). The least significant knowledge barriers were issues related to production, specifically the recovery of nutritional ingredients from side-streams (2.6 ± 1.0) in Norway and the content of nutritional ingredients in side-streams (3.1 ± 1.1) in France. In Poland, the least significant barrier was knowledge of the financial resources the company needed to improve utilisation of side-streams (3.1 ± 0.9), which is related to the availability of EU funds for fish processing.

In Poland and France, the biggest motivation for better utilisation of fish pelagic side-streams was environmental benefits through improved utilisation of bioresources and reduced waste (4.1 ± 0.9 and 4.1 ± 1.1, respectively), whereas in Norway, it was increasing revenues and profits from new directions of side-streams utilisation (4.3 ± 1.3).

The results of IDI research show that the pelagic fish processing plants, especially in Norway, are interested in opportunities to recover nutrients from fish pelagic side-streams, but emphasize the need for proven technologies, investment certainty and market demand. Plant modernisation should not take place disrupting the normal flow of production. Importantly, the opportunity to change processes is greater and less expensive for less automated processes, like in Poland. Interviews mainly from France revealed that even companies with a long history of side-stream valorisation encounter consumer resistance to novel products and face regulatory complexities related to food safety and labelling. Moreover, a gap remains between scientific innovation and practical implementation, partly due to limited access to validated technologies among traditional processors and the ongoing challenge for research institutions to engage SMEs effectively.

Summary

Pelagic fish processing generates large volumes of side-streams rich in valuable nutrients, yet their utilisation for food purposes remains limited. This study investigated knowledge-related barriers to valorising such materials in Norway, Poland, and France. The quantitative survey identified country-specific gaps: Polish companies highlighted a lack of knowledge on food-grade product development, Norwegian firms pointed to limited awareness of tax incentives, and French respondents emphasised legal uncertainties surrounding the food use of side-streams. Motivations also varied, with environmental concerns driving action in Poland and France, while profitability was the key factor in Norway. Qualitative interviews confirmed that processors recognise the potential of side-streams but emphasise the need for proven technologies, particularly in Norway, and for market demand, especially in Poland. In France, even experienced processors face consumer resistance and regulatory complexity. Across all countries, a persistent disconnect exists between research institutions and processing plants.

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Towards full utilization of seafood resources – opportunities and challenges

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Abstract

Introduction

Maximizing seafood resource use is a strategic priority for global food security, sustainability, and resource efficiency. Advances in biotechnology and processing have unlocked the potential of underutilized side-streams, for high-value applications.

Our aim was to provide an overview of how recent advances in biotechnology and processing technologies can transform underutilized seafood side-streams into high-value applications across food and non-food sectors to support future research, industry innovation, and policy development in sustainable seafood utilization.

Methods: In this work we have explored recent developments in the valorization of seafood side-streams, focusing on emerging biotechnological and processing innovations, highlighting key trends, technologies, and applications across food and non-food sectors. Both opportunities and barriers have been examined reviewing the nutritional, technological, and market potential of seafood side-streams, alongside promising advances in ingredient extraction, functionality, and product development, as well as including technical constraints, regulatory hurdles, and consumer acceptance.

Results and discussion

Enzymatic hydrolysis, membrane filtration, and green refining enable targeted extraction of proteins, marine lipids, bioactive peptides, and collagen from materials. Innovations like micro- and nanoencapsulation enhance oxidative stability, support food fortification, and enable novel uses in foods, feed and cosmetics. Tailored enzyme blends and process optimization have shifted focus from yield to functionality and health effects. Model food systems are increasingly used to assess ingredient

stability, sensory properties, and bioactivity.

Conclusion:
Seafood side-streams hold significant nutritional, environmental, and economic benefits. Realizing their full potential requires overcoming technical, regulatory, and social challenges. Achieving this will depend on interdisciplinary collaboration, continued innovation in processing and preservation technologies, regulatory support, and clear communication of the health and sustainability benefits.
This research was funded in whole within the Up4Food project (Upcycling side-streams for sustainable and healthy ingredients and new food concepts) by Norwegian Research Council (grant no. 353297), through the JPI HDHL Joint Programming Initiative “A Healthy Diet for a Healthy Life”.

Multispectral imaging as a predictive tool for freshness of whole Atlantic cod: Compared with sensory, chemical and microbiological analysis

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Abstract

This study explores the potential of using multispectral imaging (MSI) techniques to predict the freshness of whole gutted Atlantic cod (*Gadus morhua*) throughout its shelf life during storage on ice. Spectral data were acquired from key anatomical regions - the gills, skin, and eyes - and analyzed using chemometrics methods, including partial least squares regression (PLSR) and artificial neural networks (ANNs). These models were trained to predict sensory evaluations performed by trained panelists using the Quality Index Method (QIM) as well as chemical- and microbiological analyses, total viable counts (TVC) and total volatile base nitrogen (TVB-N). Among the regions analyzed, the gills provided the most accurate predictions of the QIM score, with the ANN model achieving an R2CV = 0.87 and an RMSECV of 2.0. Spectral analysis highlights the role of near-infrared (NIR) wavelengths in capturing spoilage-related biochemical and structural changes, complementing the visible spectrum, which primarily captures color changes. Our findings suggest that MSI combined with chemometric techniques could serve as an efficient, non-destructive alternative to traditional sensory freshness evaluations.

Utilisation of side-stream from blue mussel aquaculture in fish feed. Environmental footprint evaluated by life cycle assessments (LCA)

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Abstract

Introduction

Blue mussels represent the most extensively cultivated aquaculture species within the European Union. However, a considerable proportion of the harvested mussels is deemed unsuitable for human consumption due to factors such as size, or as the mussels are dead or broken. This waste-stream is normally discarded by either releasing them into the ocean, or crushing and distributing them along local roads, thereby representing a significant underutilisation of biological resources.

Simultaneously, the finfish aquaculture industry is confronted with the challenge of identifying sustainable feed alternatives that ensure adequate nutritional composition, maintain palatability, and minimise their environmental impacts. The valorisation of the blue mussel waste stream as a feed ingredient offers a potential solution to these challenges.

Aim of research

The objective of this study was to evaluate the environmental sustainability of utilising a waste-stream from blue mussel aquaculture as a fish feed ingredient through the application of LCA. For the assessment, blue mussels were estimated as processed into blue mussel meal and evaluated according to different production methodologies and footprint cohesion, and comparability with alternative protein sources.

Material and methods

The environmental footprint of blue mussels was determined through a systematic review of existing literature on LCA of mussel production. This review focused on identifying common environmental impact categories and methodological approaches across various production systems, such as longline, raft, and bottom culture.

To evaluate the environmental impacts of blue mussel meal production, the Product Environmental

Footprint (PEF) method from the European Commission was used as a baseline for a prospective LCA. Combined with the nutrient profile of mussels, the footprints were used to enable a theoretical substitution of traditional protein ingredients in commercial fish feed recipes.

Results and discussion

The environmental footprint of blue mussel meal production was found to vary significantly across impact categories. While substituting fishmeal with blue mussel meal in aquaculture feed increased the overall environmental impact, the magnitude of this increase depended on the specific impact category and the proportion of substitution. For global impact categories such as climate change, substituting fishmeal with blue mussel meal, resulted in a proportional increase in CO_2-equivalent emissions. However, certain localised impact categories, such as resource use (minerals and metals) and human toxicity (cancer), exhibited more pronounced increases.

When comparing soybean meal with blue mussel meal, global impact categories also increased with the increase of blue mussel meal. However, for local impact categories, blue mussel meal performed better. These findings highlight the variability in environmental trade-offs associated with blue mussel meal as a feed ingredient.

Sensitivity analyses revealed that the environmental footprint of blue mussel meal could be reduced by up to 80% in certain categories when using lower-impact mussel aquaculture systems. Additionally, allocating the environmental burden of mussel production between food-grade and feed-grade mussels reduced the per-unit footprint of both products, demonstrating the potential benefits of a circular approach to resource utilisation.

Conclusion

While the inclusion of blue mussel meal in fish feed increased the environmental footprint in total, its use as a feed ingredient provides a viable pathway for valorising aquaculture waste-streams and broadening the use of biomass available for sustainable food production.

Resource effective multi-extraction of sustainable high-value compounds from shrimp production side-stream: ReMeSS project - The final note

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Abstract

The shrimp peeling industry faces a persistent challenge: large quantities of waste generated during processing are either discarded or sold at very low prices for use in animal feed. Meanwhile, numerous scientific studies have highlighted the potential to extract high-value compounds from these shrimp by-products. Despite this promising research, the industry has yet to benefit, as current extraction methods are not economically viable for large-scale implementation.

The aim of the ReMeSS project - Resource effective multi-extraction of sustainable high-value compounds from shrimp production side-stream – is to solve this issue during a time frame of 3.5 years by collaborating across the entire value chain: from shrimp production to sales of nutritional and health food products.

The novel approach in ReMeSS includes the use of known knowledge of extraction processes in combination with filter/screw pressing in a multi-extraction set-up. This set-up was first presented at WEFTA in 2022, and each year we have presented the newest results. Now we are ready to present the final joint results of ReMeSS.

Kelp processing innovations – Norwegian perspectives

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Abstract

While the potential for kelp cultivation along the Norwegian coastline has been regarded as huge, there are still major commercial and technical obstacles that must be solved. One major challenge is to make kelp suitable as a food ingredient with a controlled content of iodine and potentially toxic elements (PTEs). Through several studies, we have aimed at finding and optimizing sustainable kelp processing schemes to obtain:

- Controlled and stable iodine content with limited variation in the end product
- Limited loss of dry matter content from kelp during processing or utilization of solids extracted to the processing water
- Minimum use of potable water and energy
- Maximum reduction of PTEs

The studies were made on sugar kelp (Saccharina latissima) and winged kelp (Alaria esculenta) using soaking in pre-heated potable water or sea water, pulsed electric field treatment (PEF), ultrasound treatment, acidification, and fermentation as well as combinations of these.

It was found that the initial content of iodine in fresh harvested kelp was important for the final content. The residual iodine content after processing depended on the initial iodine content of the samples. Even if more iodine was extracted from samples of high initial content compared to samples of lower initial content the final concentration of iodine was highest for the samples of high initial iodine content. It can be concluded that independent of processing methods, the choice of location and conditions for cultivation remains important. Intermediate storage of kelp under high light and low water turnover conditions slightly reduced iodine content. Subsequent blanching of stored samples resulted in an 87% reduction in iodine, compared to 80% in non-stored samples, suggesting that post-harvest storage can influence iodine reduction. Live Storage Under Stressful Conditions should be further investigated.

The efficiency of blanching has been demonstrated in several previous studies. In one of the present studies, blanching kelp in seawater with a water-to-seaweed ratio of 4, coupled with 2-3 successive baths, significantly reduced iodine content to approximately 200 μg/g dry weight (dw). This process also decreased mercury content in Alaria esculenta but not in Saccharina latissima. Iodine and arsenic were identified as limiting factors for consumption. Even if blanching may be done at temperatures as low as 45 °C with acceptable efficiency it is still quite energy intensive compared to PEF.

PEF as alternative to blanching was previously investigated in some few studies and we continued this research. PEF treatments at energy levels of 2.7 and 14.4 kJ/kg reduced iodine content by about 40% and

mercury content by 19 %, compared to no pretreatment. PEF processing required less than 10% of the energy input of traditional methods, making it a promising low-energy alternative for reducing PTEs in seaweed and this led to further studies on PEF. In our next study of kelp with higher levels of iodine, PEF processing at medium high intensity reduced iodine content by 25%, similar to the 19% reduction with blanching. PEF was more efficient at removing lead and retaining protein, suggesting it as a low-energy alternative to blanching with comparable iodine reduction and better nutrient retention.
Combining PEF and blanching treatments increased dry matter extraction to about 60%, compared to 40% with single-step processing. Extracted compounds included ash, polyphenols, and mannitol, while proteins, heavy metals, and other sugars were concentrated in the solid fractions.
PEF as a Pretreatment for Fermentation: PEF-treated kelp reached a pH below 4.5 within 24 hours and 4.0 within 48 hours during fermentation, faster than blanching and control samples. PEF also resulted in lower iodine concentrations and higher dry matter loss compared to blanching.
Overall conclusion.
These findings highlight the potential of various processing methods, particularly PEF technology, to reduce iodine and other PTEs in kelp, making it safer for consumption while retaining its nutritional value and reducing energy requirements.
Acknowledgement:
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Sund, R. (2025) Post-Harvest Processing of Cultivated Kelp for Food Production. PhD thesis. Technical University of Denmark (DTU).
Blikra, M.J, Skåra, T., Olsen, L. and Skipens, D. (2025) Enhancing extraction of iodine and arsenic from kelp by blanching in seawater. (Manuscript submitted for publication)
Blikra, M.J. and Skipnes, D. (2024) Live storage of kelp under stressful conditions led to higher iodine reductions during subsequent blanching. J Appl Phycol 36, 1407–1412 (2024). https://doi.org/10.1007/s10811-024-03204-2
Blikra, M.J. Skipnes, D. and Skåra, T. (2022) On the use of pulsed electric field technology as a pretreatment to reduce the content of potentially toxic elements in dried Saccharina latissima, LWT, Volume 169, 2022, 114033, https://doi.org/10.1016/j.lwt.2022.114033 .

Asia–Africa BlueTech Superhighway project: Climate-Smart Technologies for Reducing Aquatic Food Waste and Loss

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Abstract

Asia–Africa BlueTech Superhighway project:
Climate-Smart Technologies for Reducing Aquatic Food Waste and Loss
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The Asia-Africa Bluetech Superhighway project is a £44.5 million seven years project funded by UK International Development under the Climate and Ocean Adaption and Sustainable Transition Programme (COAST) led by WorldFish. Main aim is to boost climate-resilient, nature positive aquatic food production in targeted countries in Africa and Asia along the Indian Ocean Coast. Nofima is involved in the work package 3 – Climate smart food processing and storage technologies to reduce food loss and waste.
The talk will give a brief overview of what we do in the project in particular targeting small-pelagic fisheries in Tanzania and Mozambique a major protein source for the local communities along the coasts. The small pelagic species, dagaa, is typically sun-dried whoever during the rainy seasons the food loss could be up to 50% due to humidity. Examples of technologies, including improved drying systems and canning, that could reduce the food loss and potentially give added-value to local communities will be presented.

Impact of seasonal variations and seawater temperature on muscle quality of farmed Pacific bluefin tuna (*Thunnus orientalis*)

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Abstract

In recent years, the aquaculture of Pacific bluefin tuna (Thunnus orientalis) in Japan has expanded to meet substantial demand and ensure a stable supply. The muscle quality of farmed Pacific bluefin tuna is considered to improve in the winter season and deteriorate in the summer season. However, there is a lack of detailed information on its muscle quality change. Thus, the relationship between seawater temperature and the seasonal variation of muscle quality in farmed Pacific bluefin tuna was investigated.

Pacific bluefin tuna were farmed in the sea cages in Nagasaki Prefecture, Japan, for approximately 4 years. Sampling was conducted in May 2024 (spring), September 2024 (summer), and January 2025 (winter). All samples were subjected to a process known as ikejime, which includes destroying the brain and spinal cord and bleeding the fish, after electrical stunning by divers. The body temperature of Pacific bluefin tuna was measured after slaughter. The dorsal muscle of Pacific bluefin tuna was stored in ice for 14 days, and analyses were conducted over time.

There were no statistical differences in the weight and length of all samples. The surface seawater temperatures in the cages were approximately 18.5 °C in May, 25.2 °C in September, and 14.2 °C in January, respectively. The body temperatures of farmed Pacific bluefin tuna after slaughter were approximately 33.5 °C, 34.0 °C, and 31.7 °C in May, September, and January, respectively.

The lipid content of the May sample tended to be higher than that of the other samples. The May and January samples showed a slower decrease in the content of inosine-5'-monophosphate (IMP), a component that contributes to the umami taste of fish muscle, compared to the September sample. The January sample had higher water-holding capacity (WHC) and breaking stress than the samples from

other seasons.

The May and January samples were observed to clear myosin peak in the differential scanning calorimetry thermogram. However, the myosin peak was broad in the September sample, suggesting its conformational change. Thus, the rise in body temperature of farmed Pacific bluefin tuna was likely induced by the increase in seawater temperature in September, leading to its myosin conformational change.

Consequently, this study revealed that farmed Pacific bluefin tuna caught in January exhibited superior muscle quality owing to slow IMP degradation, high WHC, and high breaking stress. Low seawater temperature prevented the increase in body temperature of farmed Pacific bluefin tuna, resulting in the maintenance of myosin conformation.

Pullet Carpet Shell *Venerupis corrugata* (Gmelin, 1791): innovative diets to improve farming performance

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Abstract

INTRODUCTION

Clams are a globally popular seafood, especially in Asia and Europe. From the nutritional standpoint they are known for being an excellent source of high-quality protein, essential vitamins, and minerals like iron and zinc, playing an important role in terms global food security supply. Besides, as filter feeders, they have a significant ecological relevance improving the quality of marine ecosystems. Given they're low-impact farming, and the significant fishing pressure over species like pullet carpet shell Venerupis corrugata (Gmelin, 1791), the sustainable cultivation of this organisms may pave the way to ensure a sustainable production for human consumption, natural stocks recovery and biodiversity preservation.

AIM RESEARCH

Based on this, our study aimed to evaluate the effect of two distinct diets on the growth performance and lipid profile of V. corrugate farmed in the South of Portugal.

MATERIAL/METHODS/DESIGN

Two dietary treatments were tested over a two-month trial: Diet A—composed of live microalgae (Chaetoceros calcitrans, Skeletonema costatum, and Tisochrysis lutea), and Diet B—formulated exclusively with inert components. Individual clams were sampled post-trial for shell weight, edible portion (EP), total lipid content, and fatty acid profiles.

RESULTS AND DISCUSSION

Pullet carpet shell fed Diet A showed significantly greater growth (6.64 ± 1.09 g vs 4.99 ± 0.82 g) and higher EP yields (2.47 ± 0.40 g vs 1.46 ± 0.27 g), representing 37.38 ± 3.47% vs 29.17 ± 1.46% of total body weight. Although total lipid content was similar, the fatty acid composition differed among the two groups. Diet B-fed pullet carpet shell exhibited higher saturated fatty acids levels (60.2 ± 1.2% of total fatty acids) when compared to Diet A-fed individuals (55.9 ± 1.2%). Even though omega-6 polyunsaturated fatty acids (n-6 PUFA) did not different as a result of the provided diet, variations were observed in specific n-6 PUFA. Diet B led to increased levels of eicosadienoic acid (20:2 n-6) (18.2 ± 1.0% vs 8.0 ± 0.9%), while Diet A led to higher contents of docosapentaenoic acid (22:5 n-6) (9.1 ± 0.9% vs 1.5 ± 0.5%).

CONCLUSION(S)

The superior growth performance of pullet carpet shell fed with Diet A highlight that: 1) the diets composed by living microalgae, likely for being more similar to what occurs in the wild, is more suitable for the V. corrugate; and 2) Diet B still needs further improvements. Since the pullet carpet shell feeds on suspended particles in the water column, incorporating a floating capability similar to that of the microalgae used in Diet A could improve individual growth and fatty acid profiles, while also reducing mortality—ultimately enhancing production yield and farmer profitability, thus supporting local economies and coastal communities.

Three-spined stickleback as a potential new fish oil source

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Abstract

The three-spined stickleback (Gasterosteus aculeatus) is a small pelagic fish species with a long but largely forgotten history of use in the Nordic region. In recent decades, the ecological balance of the Baltic Sea has shifted, leading to a fiftyfold increase in the three-spined stickleback population since the 1980s. This significant rise has made the species a notable part of the pelagic fish biomass in the Baltic Sea.

Aim of Research: The research aimed to explore the potential of three-spined stickleback as a new raw material for fish oil production. Specifically, the study investigated the quality of raw oil extracted from stickleback, the impact of processing parameters on oil yield and quality, and the feasibility of utilizing the protein fraction.

Materials and Methods: Three-spined stickleback was caught as trawling by-catch of Baltic herring from the Gulf of Bothnia. The fish were processed using a modified fishmeal process at different temperatures (40°C, 70°C, and 95°C), with or without a proteolytic enzyme. The raw oil and protein fractions were analyzed for various parameters, including oxidation indicators, volatile compounds, fatty acid profile, and sensory properties. The microbiological quality of the raw material and the proximate composition of the dried fishmeal were also assessed.

Results and Discussion: The microbiological quality of the raw material met the requirements for feed fish. The raw oil yield was approximately 10%, with no significant effect of temperature or enzyme addition on yield. The protein fraction had a typical peptide profile for fishmeal, with enzyme treatment reducing the average peptide size. The raw oil had high levels of primary and secondary oxidation products, indicating the need for a purification process. The sensory evaluation revealed that stickleback oil had a milder odour profile compared to herring oil but stronger than salmon oil.

Conclusions: Three-spined stickleback presents both challenges and opportunities as a new fish oil source. While the quality of the raw oil is typical for fish oil and requires purification, the protein fraction is similar to fishmeal but with a higher fat content. Further research to optimize the fractionation process, as well as to develop sustainable catching methods for sticklebacks, is needed.

Developing a sustainable bait alternative for the common whelk, *Buccinum undatum*, pot fishery in Ireland

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Abstract

Bait supply, consistency and security for the economically important common whelk (*Buccinum undatum*) fishery in Ireland has recently come into focus. A decline in brown crab (*Cancer pagurus*) stocks has reduced the viability of this preferred and traditionally productive bait species. The Whelk Bait Project is an ongoing collaboration between Ireland's Seafood Development Agency (BIM) and the Marine and Freshwater Research Centre (MFRC) at ATU Galway, Ireland, which builds upon work initiated in Nofima, Norway. The research aims to develop a sustainable alternative bait for the whelk fishery, thereby reducing dependency on brown crab. The work is co-funded by the Government of Ireland and the European Maritime, Fisheries and Aquaculture Fund (EM-FAF).

Advice on project design and implementation is provided by a multi-actor stakeholder platform comprising researchers, processors, fishers and other industry representatives. During bait development, processing side-streams and underutilized species were combined with a food gelling agent (binder) to produce a low volume bait that is easy to handle and practical for fishers to implement. Laboratory trials showed that a bait containing green crab (*Carcinus maenas*) is attractive to live whelk. When tested at sea under commercial fishing conditions the gelled green crab bait produced similar catch rates compared to unprocessed green crab. Performance also compared favourably to that of the traditional brown crab bait.

Progress on the project to date indicates that the use of brown crab in the whelk fishery could be reduced by developing formulated baits from currently underutilized resources. This could contribute to achieving maximum sustainable yield (MSY) in the Irish brown crab fishery. At present, work is underway to scale up the production of an alternative formulated bait and to conduct comprehensive testing at sea. Additionally, analysis is ongoing to characterize the chemical profile of the odour plume that elicits a foraging response in whelk and to reduce bait volume using hydrolysis.

Common octopus (*Octopus vulgaris*) viscera as a source of healthy fatty acids: A comparative study with edible tissues

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Abstract

Seafood arte known to provide high contents of important constituents for the human diet. Notably, the marine fatty acid (FA) profile has been found to be responsible for different health benefits (i.e., decreases in cardiovascular, neurological and inflammatory disorders). In the current research, a comparative study of the FA composition of non-edible (viscera) and edible (mantle and arm) tissues of common octopus (Octopus vulgaris) was carried out. The effect of cooking process (40 min at 90 °C) and frozen storage on octopus specimens (4 months at −18 °C) was also analysed. In all kinds of samples, the polyunsaturated FA (PUFA) group was the most abundant ($p < 0.05$) and monounsaturated FAs showed the lowest presence ($p < 0.05$). Lower ($p < 0.05$) ω3-PUFA, ω3/ω6 ratio and docosahexaenoic acid values were detected in viscera (35.4-41.9%, 3.0-4.5%, and 12.7-17.5%, respectively) than in edible tissues (44.4-52.5%, 4.1-6.1%, and 24.3-30.1%, respectively). Conversely, higher ($p < 0.05$) eicosapentaenoic acid content was detected in viscera (19.6-21.9%) than in the edible tissues (17.2-19.3%). In most cases, the cooking process and frozen storage led to an average decrease of the PUFA and ω3-PUFA content and to an increase of the saturated FA presence. In agreement with current nutritional recommendations, all tissues showed great levels of highly-valuable indices regarding the lipid fraction. The study proves that viscera, a waste substrate, can be considered a relevant source of ω3-PUFAs for food and pharmaceutical industrial requirements. The use of viscera would lead to ecological upside of reducing seafood industry waste and agree with general commitments for environmental sustainability and circular economy.

Evaluation of partial dry-bleeding of Atlantic salmon (*Salmo salar*) and its effects on fillet quality and stability

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Abstract

Salmonid blood is an abundant by-product of the relatively large and growing salmonid industry in Iceland and has recently gained increased interest as a source of diverse valuable compounds. Blood collection has posed a challenge due to the delicate nature of both the blood and the currently most valuable final product of the salmonid industry, the fillets. This study examined the efficiency of partial dry-bleeding Atlantic salmon (*Salmo salar*) related to blood recovery and its potential effects on fillet quality compared to traditional bleeding. The quality of fillets was assessed based on parameters, including sensory attributes, physiochemical, and microbial properties for both partially dry-bled and traditionally bled salmon. The results indicated that partial dry-bleeding for 4.5 min effectively recovered blood equal to 1–2 % of the live weight of Atlantic salmon, 75 % of which was obtainable in the first minute and 90 % during the first 2 min. Aside from possibly causing a slight increase in gaping in the fillet, partial dry-bleeding neither affected the flesh quality of fresh salmon compared to traditional bleeding nor following prolonged storage on ice post slaughter. These results provide valuable insight into salmon blood collection practices and preservation treatments for its utilization potential as a valuable resource.

Optimised low-toxicity solvents for the extraction of omega-3 fatty acids, phospholipids and tocopherols from squid (*Doriteuthis gahi*) waste

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Abstract

Seafood processing is considered as one of the main sources of by-products and waste, which lead to important environmental concerns. However, seafood waste can be considered an important source of major constituents like lipids and proteins in addition to minor components such as pigments, vitamins, chitin, enzymes, and collagen. This study focused on the recovery of valuable lipid compounds from squid (Doriteuthis gahi) waste. Extraction conditions of total lipids (TLs), phospholipids (PLs), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and tocopherols were optimised by employment of a Simplex-Lattice design, which was developed considering different relative concentrations of three low-toxicity solvents (ethanol, acetone, and ethyl acetate). The optimisation process was also addressed to fatty acid (FA) group ratios. The variance analysis of multiple regression data demonstrated that the quadratic model was significant ($p < 0.05$) for TL, PL, EPA, and α-, γ-, and δ-tocopherol values and for $\omega3/\omega6$ and polyunsaturated FA/saturated FA ratios. As a result, the following optimised values were obtained: 76.15 g·kg-1 dry waste (TLs), 477.42 g·kg-1 lipids (PLs), 21.48 g·100 g-1 total FAs (EPA), 13.03 ($\omega3/\omega6$ ratio), 3.48 (PUFA/STFA ratio), 2.75 g·kg-1 lipids (α-tocopherol), 36.90 mg·kg-1 lipids (γ-tocopherol), and 2.79 mg·kg-1 lipids (δ-tocopherol). Except for the TL yield, higher values were obtained by employment of the optimised condition of low-toxicity solvents. Remarkably, the optimised mixture would depend on the bioactive lipid compound concerned (i.e., higher or lower polarity). A novel strategy based on the employment of low-toxicity solvents is proposed for the extraction of valuable lipid constituents for the human health and nutrition from squid waste. Additionally, the current eco-friendly extraction is in agreement with nowadays requirements regarding the employment of procedures which reduce the risk to toxic chemical exposure.

Development of new aquafeed formulations with higher nutritional efficacy and sustainability (PCM - 00044)

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Abstract

Aim of research

Spanish aquaculture production reached 266,000 tons in 2023, with European seabass (*Dicentrarchus labrax*), rainbow trout (*Oncorhynchus mykiss*) and gilt-head bream (*Sparus aurata*) as main fish farmed species. Fish aquaculture is highly dependent on the use of compound feeds, with national consumption in Spain reaching 181,000 tonnes in 2023. The formulation of aquafeeds is crucial to ensure the viability and sustainability of aquaculture systems. Fishmeal remains the predominant protein source in aquafeeds, with approximately 86% of its global production intended for aquafeed manufacture. The sharp increase in demand for fish meal for aquaculture and livestock farming, combined with declining fishery catches (e.g. anchovy, herring) has doubled the cost of this ingredient over the past two decades [1], which has promoted the search for alternative protein sources from animal, plant or biomass origin. To this regard, insect protein represents a sustainable alternative with nutritional composition comparable to fishmeal. They are a high-protein source, with defatted meals containing around 75% w/w of protein on a dry basis. The advantage of insect farming is its high feed-to-protein conversion efficiency. For example, producing 1 kg of cricket (Acheta domesticus) protein requires only 2.13 kg of feed, compared to 9 kg for pork [2]. To date, around 16 insect species have been investigated for feed use in aquaculture, where soldier fly (Hermetia illucens), common housefly (Musca domestica), and yellow mealworm (*Tenebrio molitor*) stand out due to their scalability, sustainability,

and nutritional value as fishmeal substitutes.

Another key focus in aquafeed formulation is the enrichment of diets with functional ingredients such as peptides, fatty acids, vitamins, or probiotics. The inclusion of protein hydrolysates in aquafeeds has been extensively studied for their benefits on survival rates and weight gain, with recommended replacement levels not exceeding 15% w/w of dietary protein content [3]. In this regard, protein hydrolysates provide low-molecular weight peptides with high digestibility and improved palatability, which has a positive impact on survival, feed utilization and growth rate [3]. Besides this, peptides and other natural compounds can display specific biological activities, such as antimicrobial, anti-inflammatory, immunomodulatory or antioxidant, among others. The incorporation of antioxidant, antimicrobial or immunomodulatory agents into aquafeeds serves several purposes: restrain lipid oxidation of aquafeeds, extending their shelf life; mitigate the oxidative stress caused by the environmental factors present in aquaculture systems (e.g. high rearing densities, presence of heavy metals or ammonia, etc) and avoid the extensive use of antibiotics in aquaculture facilities [4,5].

The project "Development of New Aquafeed Formulations with Higher Nutritional Efficacy and Sustainability (PCM_00044)", funded by the Ciencias Marinas programme, aims at the formulation of new aquaculture diets with inclusion of partially hydrolysed insect (*Tenebrio molitor*) protein. Moreover, some of the formulated diets were enriched with three different functional ingredients: (i) omega-3 polyunsaturated fatty acids (DHA, ARA), (ii) sunflower seed hydrolysates displaying in vitro antioxidant and anti-inflammatory activities, (iii) allium-derived extract containing organosulfur compounds of proven antimicrobial activities against fish pathogens. The experimental diets were tested against a standard commercial diet in European seabass (*Dicentrarchus labrax*) juveniles.

Materials and Methods

The project PCM_00044 engages a transdisciplinary consortium, led by the BIO-110 Research Group from the Department of Chemical Engineering at the University of Granada (UGR) with the collaboration of the BIO-160 Group from the Department of Microbiology (UGR) and the Aquaculture Technology Centre of Andalusia (CTAQUA). Two private partners are involved in the project, DMC Research Center Ltd. and TEBRIO Ltd. as suppliers of the allium-derived extracts and the defatted mealworm meal, respectively. As shown in the Figure 1, the project tasks are distributed into four main workpackages (WP). The first WP is devoted to the formulation of the aquafeeds. It entails the optimization of an in vitro protein digestibility protocol for insect meal, based on the INFOGEST method [6] adapted for European seabass (*Dicentrarchus labrax*). The protein feed ingredient was prepared by replacement of 25 – 75% w/w of fish meal protein by T. molitor protein, with inclusion of 15% w/w of insect meal hydrolysate at degrees of hydrolysis (DH) of 5 – 20%. This formulation was optimized by Response Surface Methodology to provide maximum in vitro digestibility. As for the lipid ingredient, it was formulated by enrichment of the standard fish oil with ARASCO® or DHASCO® (DSM Nutritional Products, Switzerland) to meet the nutritional recommendations for larval and juvenile rearing, (i.e. molar ratios DHA-EPA 2:1 and EPA-ARA 4:1). Finally, two bioactives were chosen to take part in the formulation of the experimental diets: (i) sunflower (Helianthus annuus) seed hydrolysates (DH 10%) exhibiting antioxidant (DPPH radical

scavenging and ferrous chelating) and anti-inflammatory (PLA-2 inhibitory) activities in vitro; (ii) a standardized blend of extracts derived from Allium spp., containing organosulfur compounds such as propyl propane thiosulfonate (PTS) and propyl propane thiosulfonate oxide (PTSO) with demonstrated antimicrobial properties [5].

The formulated ingredients were tested through a 12-week feeding trial in CTAQUA. This was conducted with 1,170 seabass juveniles (initial weight: 3.25 ± 0.33 g) reared in an 18-tank (100 L each) recirculating aquaculture system (RAS). Six diets formulated and tested in triplicate: (1) a commercial control diet for pre-growing seabass, serving as the baseline for 5 formulated diets; (2) a diet with 25% w/w of the protein replaced by T. molitor protein partially hydrolysed (15% w/w of total insect protein); (3) a control diet supplemented with arachidonic acid (ARA); (4) a diet enriched with sunflower seed peptides; (5) a diet containing allium-derived extracts (PTS/PTSO); and (6) a combined diet incorporating 25% w/w insect protein, ARA, and plant bioactive peptides to evaluate potential synergies. All diets were formulated to be isoproteic, isolipidic, and isoenergetic. Growth performance was monitored throughout the trial, with final biometric and immunological assessments conducted at termination.

The analysis of the harvested fish after feeding trial pursued two main objectives: (i) nutritional evaluation of fish flesh (i.e. proximate composition and amino acid profile) and lipid content (i.e. fatty acid profile of the extracted fish oil) and (ii) immunological assessment through analysis of intestinal microbiota DNA and mucus. DNA was extracted from intestines by mechanical lysis and purified using a commercial kit. A microbial diversity study was conducted by high-throughput sequencing using an Illumina platform. Finally, the techno-economic assessment comprised two main tasks: (i) an analysis of the main farmed fish and aquafeed producers in Andalusia (Southern Spain), focusing on production capacity and cost structures, and (ii) an evaluation of the technical feasibility and economic viability of incorporating partially hydrolysed insect protein into aquafeed formulations.

Results and discussion

Final zootechnical performance was evaluated among experimental groups in terms of survival rate (SR), specific growth rate (SGR), feed conversion ratio (FCR), Fulton's condition factor (K) and hepatosomatic index (HSI). The Table 1 shows the main zootechnical parameters evaluated at the end of the feeding trial. The survival rate exceeded 95% for all the dietary treatments, with a final body weight surpassing 40 g in all experimental groups at the end of the feeding trial.

No significant differences were detected between diets (95% confidence interval), indicating that the replacement of 25% fishmeal protein with insect meal protein, along with fatty acid and bioactive supplementation, had no detrimental effect on the normal growth performance of juvenile sea bass. These findings validate the use of partially hydrolysed insect meal as a viable protein source in sea bass diets.

The proximate composition of harvested fish did not show significant differences among the

experimental diets, except for the lipid content, which was slightly higher in Diets 5 and 6 (moisture 66.4–68.2% w/w; mineral matter 3.5–3.8% w/w; protein 16.5–16.7% w/w; fat 11–13% w/w). The fatty acid profiles of sea bass oil, determined by direct gas chromatography, are currently being analysed. Preliminary results show significant levels of omega-3 fatty acids (EPA, DHA, ALA) with an estimated DHA/EPA ratio between 1.5–1.6. Regarding the muscle amino acid profile of sea bass, essential amino acids account for 29–31% w/w, with lysine (6.6–7.1% w/w), aspartic acid (7.2–7.7% w/w), and glutamic acid (9.9–10.5% w/w) being the most abundant.

Conclusion

This study supports the feasibility of replacing fish meal by partially hydrolysed insect meal, as well as supplementation with functional ingredients such as omega-3 fatty acids, plant biopeptides and allium-based extracts in European seabass feeds without detrimental effect on zootechnical performance. Immune response and gut microbiota profiling analysis, which are currently in progress, are necessary to confirm the effect of the experimental diets on reared fish.

References

1. Ahmed, N.; Thompson, S.; Glaser, M. Global Aquaculture Productivity, Environmental Sustainability, and Climate Change Adaptability. Environ Manage 2019, 63, 159–172.
2. Cadinu, L. A., Barra, P., Torre, F., Delogu, F., & Madau, F. A. (2020). Insect Rearing: Potential, Challenges, and Circularity. Sustainability 2020, Vol. 12, Page 4567, 12(11), 4567.
3. Siddik, M.A.B.; Howieson, J.; Fotedar, R.; Partridge, G.J. Enzymatic Fish Protein Hydrolysates in Finfish Aquaculture: A Review. Rev Aquac 2021, 13, 406–430.
4. Aklakur, M. Natural Antioxidants from Sea: A Potential Industrial Perspective in Aquafeed Formulation. Rev Aquac 2018, 10, 385–399.
5. Cabello-Gómez, J. F., Aguinaga-Casañas, M. A., Falcón-Piñeiro, A., González-Gragera, E., Márquez-Martín, R., et al. (2022). Antibacterial and Antiparasitic Activity of Propyl-Propane-Thiosulfinate (PTS) and Propyl-Propane-Thiosulfonate (PTSO) from Allium cepa against Gilthead Sea Bream Pathogens in In Vitro and In Vivo Studies. Molecules, 27(20).
6. Brodkorb, A., Egger, L., Alminger, M., Alvito, P., Assunção, R., et al. (2019). INFOGEST static in vitro simulation of gastrointestinal food digestion. Nat. Protoc. 2019 14:4, 14(4), 991–1014.

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Assessing pelagic fish biomass through ddPCR Analysis of eDNA and eRNA

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Abstract

Aim:
This study investigates the use of environmental DNA (eDNA) and RNA (eRNA) as a tool for monitoring pelagic fish stocks across a large spatial scale. Specifically, we assess how well molecular concentrations correspond to fish biomass estimates from trawl surveys. We also compare eDNA and eRNA concentrations in surface waters and deeper layers to explore how these molecules are distributed through the water column.
Methods:
During the annual pelagic stock assessment cruise aboard R/V Jákup Sverri, quadruplicate water samples were collected at three depths: 5 m (surface), 60 m (midwater), and 500 m (bottom), using Niskin bottles mounted on a CTD (Conductivity, Temperature, Depth) rosette. In total, 332 samples were collected at 33 stations across the Faroe Islands' Exclusive Economic Zone. DNA and RNA were extracted in the laboratory and quantified using digital droplet PCR (ddPCR) assays targeting mackerel (Scomber scombrus) and herring (Clupea harengus) from all locations. ddPCR data were then compared to biomass estimates from Catch Per Unit Effort (CPUE), to evaluate how well eDNA and eRNA reflect fish abundance across depths and locations.
Results and discussion:
All samples yielded high eDNA and eRNA concentrations; however, ddPCR results varied with sampling depth. Surface samples (5 m) produced ddPCR amplification results that closely mirrored CPUE-based biomass patterns. In contrast, ddPCR results from midwater (60 m) and bottom (500 m) samples did not reflect CPUE patterns, despite similar nucleic acid yields. Notably, ddPCR results for eDNA and eRNA were highly compatible, showing consistent spatial patterns across depths and stations.
Conclusions:
Our findings indicate that eDNA and eRNA from pelagic fish are most reliably detected—and biologically

relevant—at the depth where the fish are actively present, with limited vertical dispersal of molecules. The strong correlation between eDNA and eRNA suggests both are reliable proxies for fish biomass, with eRNA potentially offering greater sensitivity due to its faster degradation rate. These findings lay the groundwork for ongoing work using vessel-based underway systems—drawing seawater from 5–8 m—as a practical, scalable tool for routine molecular monitoring of pelagic fish stocks.

Biochemical and quality changes in Pink salmon (*Oncorhynchus gorbuscha*) during sexual maturation: Implications for food use

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Abstract

Aim of research:
The study aimed to investigate quality changes in pink salmon (Oncorhynchus gorbuscha) during sexual maturation, with the goal of assessing its potential as a food resource. Given the species' invasive status in Norway and the increasing biomass being removed from rivers, the research sought to determine whether pink salmon, particularly those caught in rivers, could be utilized for human consumption.

Material and methods:
Pink salmon were collected from both marine and freshwater environments and categorized into four sexual maturation stages (MS 0–3) based on external characteristics. Analyses included chemical composition (water, protein, fat, ash), fatty acid profiles (SFA, MUFA, PUFA), and fillet color (sensorial, SalmoFan™, and instrumental CIELAB measurements). Quality changes during chilled storage of thawed fillets were evaluated using a modified fillet index method

Results and discussion:
Significant changes in muscle composition were observed with increasing maturation: water content increased, while protein, fat, and ash decreased. Fatty acid content (SFA, MUFA, PUFA) declined with maturation, though pink salmon still provided sufficient EPA and DHA to meet daily nutritional recommendations. Fillet color degraded significantly in MS-3, becoming grayish and less intense. MS-0 fish had the best initial quality but showed the greatest deterioration during storage. Conversely, MS-3

fish, though initially of lower quality, exhibited minimal changes during storage, possibly due to fasting and lower fat content.

Conclusion:
Pink salmon undergo substantial biochemical and visual changes during maturation, affecting their suitability for consumption. Despite lower fat content compared to Atlantic salmon, pink salmon - especially in early maturation stages - can be a valuable protein and omega-3 source. The study supports the potential for utilizing pink salmon as a sustainable food resource, provided proper handling and processing methods are implemented.

Seafood intake and impact on the Omega-3 Index

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Abstract

INTRODUCTION

The omega-3 index (O3I), is defined as the sum of eicosapentaenoic acid (EPA, 20:5 n-3) and docosahexaenoic acid (DHA, 22:6 n-3) expressed as a percentage of total fatty acids present in erythrocyte membranes. This index has gained relevance for being inversely associated with mortality from cardiovascular diseases, being often used as a reference biomarker to predict the risk of developing certain coronary artery disease outcomes, such as fatal ischemic heart disease, acute coronary syndrome, or sudden cardiac death.

AIM RESEARCH

Considering that the incorporation of both EPA and DHA in erythrocytes membranes relies almost exclusively upon the diet and the relevance of marine fish for achieving the advised intake of these fatty acids, this study aimed to evaluate the O3I among the Portuguese population and correlate it with the participants seafood consumption.

MATERIAL/METHODS/DESIGN

A representative sample of the Portuguese population (n = 1 126) was evaluated through blood collection for O3I determination, where EPA and DHA levels were quantified by means of gas chromatography. The participants were also asked to complete a structured questionnaire about their

seafood consumption frequency and other relevant data (like age, physical activity, tabagic habits, among others).

RESULTS AND DISCUSSION

The majority of the population referred to consume between two and four weekly seafood meals and presented an overall O3I of 4.82 ± 2.30% — falling within the range of 4 to 8% which is indicative of an intermediate risk of cardiovascular disease. Yet, O3I was significantly higher, approximately 6.0 %, in participants taking three or more weekly seafood meals. Interestingly, increasing intake beyond this level—up to daily seafood consumption—did not produce further improvements in O3I. It should be highlighted that only 6.8% of the participands had a high O3I (> 8%, which is considered a key threshold to reduce cardiovascular disease risk). The prevalence of O3I above 8% was higher among the 50 - 59 (10.8%) and 60 - 69 (12.4%) age groups, and lower among those aged 18 to 49 (consistently below 5%), thereby correlating with seafood consumption frequency. The 70 - 79 age cohort occupied an intermediate position (8.3%). The results also showed that participants lifestyles are relevant, with significant higher O3I being determined in individuals that reported to practice exercise (9.1% vs 4.9%)and to not smoke.

CONCLUSION(S)

Even though the O3I found among the Portuguese population was below the recommended threshold of 8%, these results show it can be significantly improved through the adoption of dietary habits that privilege seafood consumption — particularly of species known to be richer in EPA and DHA, like pelagic fish — alongside healthier lifestyle practices, including regular physical activity and no smoking.

Oxidation of herring oil and effect of antioxidants

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Abstract

Processing of Pelagic fish, such as mackerel and herring yield valuable food grade side-streams (viscera, heads, cut-offs, bone, skin) predominantly used for feed. Only in Norway, pelagic fish side-streams accounted for 226 000 tons in 2021. These side-streams are rich sources of long-chain omega-3, monounsaturated fatty acids, and high-quality proteins. Therefore, there is a huge interest to process these valuable materials into ingredients for human consumption: e.g. herring oil and proteins.

North Atlantic herring oil is characterised by high levels of the long chain monounsaturated fatty acid cetoleic acid (22:1 n11) and moderate levels of the healthy omega – 3 fatty acids such as EPA and DHA. To successfully enter the human consumption market – stability and quality of the herring oil is very important to control.

In the Impress and Up4Food projects we studied how processing of the herring oil affected the composition and stability of the oil. Crude herring oil from North Sea herring produced by industrial pilot plant was used in this study. The crude oil was bleached in the research pilot plant at SINTEF. Bleached herring oil was further processed using short-path distillation equipment, aided by a working fluid.

Effect of different antioxidants and its concentration, and storage temperature on the oxidative stability of the herring oil after each processing step was studied using accelerated stability methods (OSI – oxidative stability index and Schaal oven test) and will be presented.

The authors acknowledge the ERA-NET BlueBio Programme project IMPRESSIVE grant No. 341732 of RCN and FOODRETEC Programme project «Up4Food» (Upcycling side-streams for sustainable and healthy ingredients and new food concepts) grant No. 353297 of RCN.

Novel insights into herring (*Clupea harengus*) hemoglobins and their ability to promote heme-mediated lipid oxidation

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Abstract

Increasing the direct use of herring (Clupea harengus) in food production is hampered by its fast sensorial deterioration post mortem, largely driven by hemoglobin (Hb)-mediated lipid oxidation. Herring Hb has been shown to be particularly pro-oxidative compared to Hb from other fish, but still, little is known about its properties. The aim of this study was to determine the number of herring Hb isoforms present and to unravel their structure and pro-oxidative characteristics; denaturation temperature, autoxidation, heme-loss, and pro-oxidative properties towards fish muscle membrane lipids. Trout Hb IV was used as a control since it is well characterized.

FPLC-based separation revealed three main herring Hb isoforms, where the anodic fraction constituted ~64 % and the collective cathodic fractions F1 and F2 formed the other 36 %. The anodic Hb, forming the most abundant fraction, was subjected to X-ray crystallography, showing that it is an $\alpha 2\beta 2$ tetramer with one alpha and one beta chain sequence. When added to a washed cod mince model system at pH 6.7, herring anodic Hb and herring cathodic Hb F2 were found to be the most pro-oxidative. These Hbs also showed the highest autooxidation rate at pH 6.3, 6.5 and 6.7, confirming the pronounced pro-oxidative nature of metHb. In addition, they had the lowest denaturation temperature, revealing the weakest structural stability. All Hbs oxidized faster at reduced pH, which is aligned with their Bohr and Root effects and pinpoints the critical impact of low post mortem muscle pH´s.

That the two dominant herring Hb isoforms showed higher instability and stronger oxidative properties compared to trout Hb IV likely explains the high susceptibility of herring muscle to lipid oxidation. Indeed,

these properties are expected to be enhanced by the high Hb-levels of herring muscle, and its lower post mortem muscle pH compared to e.g. trout. Our results are expected to facilitate the tailoring of strategies to limit lipid oxidation in herring, thereby paving the way for new sustainable blue value chains from fish landings currently underutilized for food.

Fermented fish products from Baltic herring (*Clupea harengus membras*)

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Abstract

Aim of research
Baltic herring (Clupea harengus membras) is healthy food rich in protein, polyunsaturated fatty acids (EPA, DHA, α-linoleic acid, linoleic acid), minerals (Ca, P, Mg, iodine, selenium), and vitamins (A, E, D, B9, B12). However, the consumption of Baltic herring food products in Finland is very low. Especially younger consumers dislike the sensory quality of the current products on the market. It is therefore extremely important to find means to turn this underutilized fish into next generation food products that meet the sensory quality of the consumer preferences.

Material and methods
In our study, the controlled fermentation of Baltic herring by two commercial starters containing lactic acid bacteria (LAB) was used. The microbiological (food-borne pathogens and spoilage microbes) and chemical safety (histamine) were analysed using the agar-based methods and an enzymatic method, respectively. The sensory quality of the fermented Baltic herring samples was evaluated by the trained panel using a quantitative descriptive method.

Results and discussion
The counts of the food-borne pathogens and spoilage microbes as well as histamine remained below the detection limits. Low pH after fermentation indicated that the LAB strains in the starters produced organic acids inhibiting microbial growth. Histamine concentration of Clupeidae family (sardines, herring) fish products may increase during LAB fermentation resulting in increasing chemical risk. Based on the results, it did not happen with the starters we used.
Thus, based on those results, our fermented Baltic herring products were microbiologically and

chemically safe according to the EU's European legislation on microbiological criteria for foodstuffs ((EC) No 2073/2005) and the Finnish Food and Drink Industries' Federation recommendations 2022.
The sensory quality of the products varied between the starter cultures. The study demonstrated the potential of fermentation to produce healthy fish products with improved sensory properties.

Conclusion
We present the first time a short-term controlled fermentation process for producing next generation safe, tasty and healthy fish foods from Baltic herring.

Effect of salt type on the ripening of marinades from Baltic herring fillets

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Abstract

Knowledge gap and aim of research: Cold fish marinades account for a significant part of the production of fish preparations in Europe. One of the main ingredients for marinating is salt, which comes in several types, differing in the composition of impurities and the method of obtaining them. The effect of the type of salt is well-known for salted fish, but there is a lack of knowledge on the effect of impurities on enzymatic ripening of acidic marinades.
Material/methods/design: The effects of different salt-types was investigated during classic marination of fresh Baltic herring fillets on a laboratory scale using vacuum brine (pure NaCl), rock salt and iodized salt. Tests were also done in model systems comprising purified cathepsins together with impurities present in the tested salts. The fillets were marinated in a marinating brine containing 4 % acetic acid and 5 % salt for 7 days at 4 °C. Physicochemical analyses were performed according to AOAC and ISO methods, while protease activity analysis and sensory evaluation were performed using methods optimized for marinades.

Results and discussion: The type of salt used in the marination process influenced both the biochemical changes and technological yield of the herring fillets. Fillets marinated with rock salt exhibited the lowest marination yield, suggesting effect on water retention and structural linking with proteins during processing. In contrast, iodized salt led to the highest yield, likely due to inhibited enzymatic softening and altered osmotic balance.
The salt type also modulated protease activity responsible for ripening. Compared to pure salt, rock salt preserved a more favorable proteolytic profile, promoting moderate softening and development of ripened flavor. Samples with rock salt showed higher peptide and free amino acid content than those marinated with iodized salt, but slightly lower than with pure salt, indicating partial inhibition of

proteolysis.

Model experiments with purified cathepsins B, D and L confirmed that the specific ionic composition of salt significantly affects enzyme activity. Chloride salts ($CaCl_2$, $MgCl_2$, $CuCl_2$) increased activity of cathepsins L, had slight effect on cathepsin D and decreased activity of cathepsin B, whereas sulfate salts ($FeSO_4$, $CuSO_4$, $MgSO_4$) strongly inhibited enzymatic action by over 60-90% all cathepsins compared to control.
This supports the hypothesis that trace mineral content in rock salt may contribute to enzyme modulation. Unlike iodized salt, which markedly suppressed all major proteases, particularly cysteine cathepsins, rock salt allowed partial enzyme activity to continue, resulting in improved sensory traits such as softer texture and more pronounced ripening aroma. Additionally, the use of iodized salt led to more compact fillet structures with limited myofibrillar delamination because of the lowest proteolysis. Overall, salt type had a notable effect on yield, proteolysis, and sensory properties of the marinated fish. The observed differences can be attributed to both ionic strength and specific interactions of anions and cations with muscle proteins and enzymes.

Conclusion: Salt type significantly influenced the ripening and technological quality of marinated herring. Rock salt, due to its balanced impact on protease activity and water retention, provided the most desirable compromise between yield and flavor development. Iodized salt impaired ripening and reduced marination yield via strong inhibition of proteolytic enzymes. Model tests confirmed that the salt's anion type plays a critical role: chloride salts generally promoted enzyme activity, whereas sulfates inhibited it. These findings suggest that careful selection of salt, especially considering its mineral composition, is essential in optimizing the quality of marinated fish products.

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Innovative processing strategies for small-sized Baltic herring and comprehensive nutritional profiling of derived cuts

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Abstract

Baltic herring (Clupea harengus membras), a small pelagic fish species, is nutritionally very valuable due to its high content of digestible proteins, essential amino acids, long chain (LC) n-3 fatty acids, minerals, and vitamins. In addition, it has a very low CO2-footprint, equal to pulses. Despite its potential both in the ongoing food protein transition and as a route to raise food security, on average less than 20% of the landings in countries adjacent to the Baltic Sea is currently used for human consumption. Instead, the majority is processed into fishmeal and fish oil for feed purposes. One major challenge hindering wider food application from current landings of Baltic herring is that the fish is very small-sized, which limits compatibility with traditional processing equipment. In response, innovative tailor-made processing lines have been developed to enable “nobbing” (i.e. de-heading plus partial gutting), belly cleaning (de-heading and full visceral removal) or filleting (i.e., head, viscera, and spine removed) of small-sized fish such as Baltic herring. However, systematic nutritional and yield investigations of the outcomes from these processes remain limited. This study, which is part of several projects, e.g., RE-BLUE, Pelagic 2.0 and Blue Food, aimed to characterize the yield as well as macro- and micronutrient composition of three different cuts derived from Baltic herring sized <55g: (i) nobbed, (ii) belly cleaned, and (iii) filleted, using whole fish as a control.

Initial results have revealed that the weight yields in nobbing and belly cleaning are 75.2% and 67.6%, respectively and that crude protein and crude lipid contents of whole, nobbed and belly cleaned cuts are 11.0% and 6.2%, 11.5% and 6.1%, and 12.2% and 3.5%, respectively. After mince production, proteins in all these samples were up-concentrated by ~6% while the lipid content was reduced by ~37%. Ongoing investigations focus on detailed micronutrient profiles (i.e. LC n-3 PUFA, Vitamin B12, Vitamin D, macro-elements and trace elements) of the above sample types, as well as fillets. The study provides a scientific basis for developing a next-gen intermediate fish raw materials which are ready-to-use for

industry or consumers, thereby enhancing and diversifying the utilization of small pelagic fish resources beyond traditional marinades, supporting sustainable food innovation.

Maximizing omega-3 health benefits: the gilthead seabream case-study as a reflection on the challenge of harmonizing sustainability, affordability, quality, safety, and health

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Abstract

INTRODUCTION

Seafood products are an excellent source of long-chain ω3 polyunsaturated fatty acids (ω3 PUFA), such as eicosapentaenoic (EPA, 20:5 ω3) and docosahexaenoic acid (DHA, 22:6 ω3), but fish and other edible marine organisms are mostly overexploited resources. This has fostered the growth of aquaculture production. There are advantages and drawbacks in replacing wild by farmed fish. Equating and balancing environmental sustainability, affordability to consumer, quality (including nutritional content), safety, and health benefits is a difficult exercise and a challenge to related stakeholders and researchers. In particular, gilthead seabream (Sparus aurata) is paradigmatic and well-suited to be a case-study. Indeed, it is a savoury and economically important fish species of the Mediterranean basin and neighbouring areas. Due to its characteristics, it has become one of the major farmed fish species in this geographic area. Wild seabream presence in the market is currently less important and, as a scarce resource and product, it commands a much higher price than farmed seabream. Its nutritional quality is generally high in wild fish, but it is subject to feed composition traits in the case of farmed fish.

AIM RESEARCH

Given the aforementioned background, this study's goal is to integrate the sustainability, affordability, quality, safety, and health aspects using the gilthead seabream as case-study and the FA profile data as key parameters in a whole innovative mathematical model and to find out whether farming fish brings about a net benefit not only in affordability, but also in the other dimensions.

MATERIAL/METHODS/DESIGN

Statistically representative number of farmed and wild seabream samples (30 of each type) were bought in a local Portuguese retailer and from a local fisherman, including in different months and consecutive years. The FA methyl esters (FAME) were determined by the Lepage and Roy procedure as modified by Cohen and co-authors, involving an acid catalyzed transesterification and the analysis of the final extract by a gas chromatography system coupled to a flame ionization detector, using specifically a Scion 456-GC gas chromatograph (West Lothian, UK), equipped with a capillary column DB-WAX (Agilent Technologies, Santa Clara, USA) (film thickness, 0.25 mm), 30 m × 0.25 mm i. d. FAME identification was based in retention time, using a standard mix (PUFA-3, Sigma-Aldrich) as reference. Results were expressed both as percentage of total FA as well as in mg/g dry weight (dw) of edible part. The absolute content was calculated through the internal standard (21:0) methodology. Statistical analysis comprised an analysis of variance (ANOVA) using Statistica™ v.12 software (StatSoft, USA). Means were compared and significant differences ($p<0.05$) were determined according to Tukey's honest significant differences (HSD) test. Finally, mathematical modelling of health impacts and other aspects was carried out by integrating input variability (full probabilistic approach) and, in particular, by applying the Extreme Value Theory (EVT) to evaluate risks and benefits and calculating the probability of exceeding specific dietary recommendations or acceptable thresholds, thereby quantifying impacts and finding maximal benefit.

RESULTS AND DISCUSSION

There were significant differences between the wild and farmed FA profiles of gilthead seabream. In particular, this was the case of the ω3/ω6 ratio. In fact, while farmed fish presented relatively low ω3/ω6 ratios below unity, wild fish displayed ω3/ω6 ratios in the vicinity of the 2.5-5.0 range. As to the absolute profiles, there was also a significant contrast in that cultivated seabream had a higher total of identified FA than wild seabream, being determined 174.3-351.9 mg/g dw vs 76.9-288.0 mg/g dw, respectively. Because total FA level is a proxy for the lipid content, this indicates that farmed fish were in average fatter than wild fish. Thus absolute FA levels were generally higher in farmed gilthead seabream. This was observed for most FA with exception of 20:4ω6, EPA, and 22:5ω3. Regarding DHA levels, while they varied between 4.27 % and 5.66 % of the total FA in farmed seabream, they were higher in wild seabream, ranging between 5.28 % and 9.23 % of the total FA. EPA range was 1.66-2.08 % in farmed seabream and 3.01-8.11 % in wild seabream. Thus, wild fish were richer in DHA than farmed fish, but were much richer in EPA than their reared counterparts. This may be due to farmers' concern in providing a DHA-rich diet to their fish and this shows the key dependence of the fish nutritional quality and healthiness on diet. The American Heart Association recommends a daily combined amount of 500 mg of EPA+DHA. Wild seabream contained up to 900 mg/100 g ww of EPA+DHA and farmed seabream had up to 700 mg/100 g ww of EPA+DHA. On the other hand, wild fish were generally richer in saturated FA (SFA) than farmed fish, whose daily intake should not surpass 20 g. Whereas SFA in wild fish was near 1000 mg/100 g ww, SFA

reached 2800 mg/100 g ww in farmed fish. Accordingly, for plausible seabream consumption scenarios of 1 monthly meal to three weekly meals of 150 g, though a generally higher probability of meeting EPA+DHA requirements was calculated for wild fish, farmed fish also supplied a substantial share of EPA+DHA needs even with 1-2 weekly meals. Such not so high consumption frequency was also advisable in order to limit SFA intake and the risk of exceeding the corresponding daily threshold. A feed largely based on vegetable ingredients instead of fish meal and fish oil rendered a farmed product more sustainable by reducing pressures on marine ecosystems. Moreover, considering that farmed seabream is cheaper by a factor of 4-5, a 2 weekly meal of farmed seabream was more advantageous than 1 weekly meal of wild seabream after pondering all major factors —by less than half the price, an equivalent or higher EPA+DHA-associated benefit without a serious risk of overcoming SFA threshold was achieved. Finally, given quality control of water and diet, farmed fish can be safer than wild fish, for instance, in the case of micro- and nanoplastics.

CONCLUSION(S)

This study showed that after integrating and pondering the dimensions of sustainability, affordability, quality, safety, and health, in the case of gilthead seabream and its wild vs farmed dichotomy and in an European context, farmed fish could be a better choice that maximized overall benefits with limited downsides, being 1-2 weekly meals advisable.

Colour, health, and hurdles: unlocking spirulina's potential in functional beverages

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Abstract

Aim
This study investigated the applicability of phycocyanin-rich UltraSpirulina as a functional ingredient and natural colourant in a sports drink, with emphasis on pigment stability, nutritional integrity, and sensory acceptability under processing and storage conditions typical for acidic beverages.

Materials and methods
UltraSpirulina was formulated into a vitamin B12-enriched sports drink prototype (pH 3.2–3.8). Spectrophotometric monitoring was performed at 618 nm and colorimetric evaluation in the CIELAB space under controlled exposure to light (500–800 lux), temperature (4 °C and 22 °C), and time (0–14 days). Sensory analysis involved 12 trained panellists scoring 12 samples on 6 attributes (colour intensity, taste, mouthfeel, off-flavour, and overall impression) using a 9-point scale.

Results and discussion
Phycocyanin showed significant degradation under light and acidic conditions, with a 52% loss in absorbance at 618 nm after 7 days in light at room temperature. Corresponding colourimetry data indicated a decrease in b* values and an increase in $\Delta E > 3$, indicating visible colour change. Sensory analysis revealed high variability in consumer perception, with off-flavours identified in 42% of samples.

Conclusions
While UltraSpirulina contributed valuable nutrients (active B12, iron, protein) and a unique natural blue hue, its limited stability under acidic and illuminated conditions compromises product shelf life and sensory appeal. Future efforts will focus on encapsulation, pH buffering, and protective packaging to improve functionality in commercial beverage systems.

Turning seaweed into functional food & feed ingredients

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Abstract

The SuproSea project evaluates the potential of proteins and high-value compounds extracted from seaweed for use in food and feed applications. The focus is on assessing their nutritional, techno-functional, and sensory properties to determine their suitability in various product formulations.

The effect of cultivation conditions on the biochemical composition of three key seaweed species (Saccharina latissima, Ulva fenestrata, Palmaria palmata) is being investigated. Biomass yield and protein composition are monitored under varying growth conditions to define optimal cultivation strategies.

Seaweed biomass undergoes various pretreatment and protein extraction methods to enhance yield and quality. High-value compounds such as polysaccharides and pigments are also extracted using a cascading approach and according the zero waste concept. The impact of these techniques on the quality and quantity of recovered compounds is evaluated.

Protein samples are analyzed for amino acid composition, in vitro digestibility, and techno-functional properties including solubility, viscosity, emulsifying capacity, and gelling behavior. Valuable polysaccharides and pigments are further characterized for heat stability, solubility, hydrophobicity, and antioxidant capacity.

Based on these results, selected protein fractions will be incorporated into model food systems (e.g., sausage, mousse, protein bar) to study their interactions with other ingredients under varying pH, salt, and temperature conditions. Proteins with favorable solubility are also being tested in high-moisture extrusion (HME) to assess their suitability for fibrous meat analogues. In parallel and in order to reach zero-waste, poultry and shrimp feed trials are being conducted to evaluate nutritional value and health effects, including growth performance and feed conversion ratios. Together, these integrated

approaches aim to support the development of sustainable, high-quality seaweed-based ingredients for future food and feed applications.

Functional seaweed hydrolysates for food application: an in silico prospecting approach

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Abstract

Seaweeds are considered as promising sustainable bioresources for food and health use. While reports on their bioactivities for health promotion have been increasing over the years, their functionalities in food systems have been less explored. This current work aims to demonstrate the applicability of in silico prospecting in the discovery, preparation, and validation of functional hydrolysates from seaweeds for food application. Our previous work has shown that multifunctional hydrolysates and pure peptides exerting anti-inflammatory and antidiabetic activities can be derived from Pacific Dulse (Devaleraea mollis) using an in silico-based prospecting, screening and in vitro validation approach. By employing the same strategy, in silico-prospected antioxidant peptides (AOP)-rich seaweed hydrolysates are generated using Ulva fenestrata (UF), Saccharina latissima (SL) and Palmaria palmata (PP) cultivated in Sweden. The theoretical degrees of hydrolysis of seaweed proteins were comparable among species showing the importance of protease selection in hydrolysate preparation. Bromelain hydrolysates had higher AE scores reflecting more frequent release of antioxidant peptides for each algal protein substrate. UF hydrolysates were predicted to contain more known antioxidative di- and tripeptides arising from annotated Ulva membrane proteins. Candidate hydrolysates are now to be tested using a range of assays and model systems to gain deeper understanding of the complex antioxidant cocktail in seaweeds that can be maximized as food ingredients. Their application in nutritious seafood materials that are challenged by high susceptibility to lipid oxidation can be a promising means to improve product quality and stability, with potential of expanding seafood product diversity. Altogether, this work shows how machine learning can be leveraged as a low-cost and time-efficient approach in strategizing processing options to yield functional seaweed ingredients for targeted food applications.

The use of farmed common carp (*Cyprinus carpio*) meat for the production of innovative fish snacks

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Abstract

The extraordinary popularity and high consumption of snacks by consumers, especially young people and children, has led to the dynamic development of this food group and its wide range of products. Snacks are enriched with, among others, dietary fiber, vitamins or minerals, and all these solutions are based on the use of plant materials, fruits, vegetables or cereals. Therefore, it was decided to use fish meat to develop innovative starch-fish snacks, which can be a tasty and healthier alternative to salty, and not only, snacks. By adopting this assumption allowed us to achieve several goals: to use the side streams of fish processing, to eliminate the reluctance to eat fish due to its unpleasant smell, problems with culinary preparation and a large number of pin bones, to change the perception of fish products as inconvenient food and, at the same time, to increase the consumption of fish in Poland also by children and adolescents.

Analyzing the supply and demand for fish in Poland, it was decided to use farmed carp meat to increase the nutritional value of starch snacks. Common carp is one of the highest quality farmed fish that can

also be certified as organic food, which cannot be done with wild fish. Fish consumption in Poland is still not high (approx. 14 kg/capita/year), wherein sea fish are mainly consumed, while the consumption of freshwater fish is negligible. Despite the fact that Poland has the largest area of carp ponds in the European Union and the largest carp production potential, carp in Poland is still a Christmas Eve fish, consumed mainly during the Christmas period. And that is why the average annual consumption of carp for years has been approximately 0.5 kg per capita. This is mainly due to the difficulty in processing this raw material, due to the thick back bone, large rib bones, as well as the large number of pin bones found in the carp meat. For this reason, when choosing fish, consumers more often choose saltwater fish. The addition of carp meat to starchy snacks increased the amount of easily digestible and high-value protein supplied, including exogenous amino acids, especially available lysine, and omega-3 fatty acids, including EPA and DHA. In addition, the use of carp meat for the production of snacks will contribute to an increase in demand for farmed carp not only during the Christmas period.
The study analysed the effect of adding carp meat on the quality of the produced starchy snacks, as well as their nutritional value, determined by, among others, the amount of protein, the digestible form of the exogenous amino acid – lysine and the amount, composition and profile of fatty acids.

Keywords: common carp; starchy snacks; easily digestible protein; exogenous aminoacids; available lysine, fatty acids; EPA; DHA

Development of a phage cocktail for the shelf-life extension of *Nephrops novegicus*

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Abstract

The Norway lobster (Nephrops norvegicus), also known as langoustine, is economically the most important crustacean in the UK, with an annual value reaching £100 million. However, harvested langoustines spoil quickly, typically remaining fresh for only 3 to 5 days. This is caused by specific spoilage organisms (SSOs) – naturally occurring, non-harmful bacteria that grow rapidly in seafood. The accumulation of bacterial metabolites leads to unpleasant odours, resulting in ~30% of the still-edible product being rejected by the customers and discarded as a waste.

Bacteriophages (commonly known as phages) are viruses that specifically infect and kill bacteria. They are the most abundant organisms on Earth and are easily isolated from the environments where their bacterial hosts are found. Due to their high specificity and effectiveness, they are ideal candidates for biocontrol of the bacteria in sectors where antibiotic use is restricted, such as the food and seafood industry. As phages form a part of human natural microbiome, they are harmless to humans and safe to use. For example, in the United States they are recognized as safe for use in food applications (GRAS status). Finally, phages are already being used successfully in agriculture, for example, to combat bacterial rot in potatoes and improve crop yield.

In this study, we have identified and isolated a range of phages that specifically target the dominant SSOs responsible for spoilage in freshly caught langoustines. Subsequently, we have assessed their impact on the natural langoustines' microflora and the formation of the malodour causing metabolites such as trimethylamine in a 14-day degradation trial. Our research demonstrated that phages can be used to suppress the growth of bacteria that generate undesirable smells, thereby extending the shelf-life of langoustines.

Materials and methods:
Nephrops norvegicus were obtained from the Clyde Sea area, Scotland, United Kingdom (UK) from a commercial fisherman. Langoustines were washed with seawater before being packed individually in polyethylene plastic bags, stored on ice and transported to the University of Leicester within 24 hours. There, they were stored on ice at 4°C for further analyses.

Specific spoilage organisms were isolated from the dissected abdominal flexor muscle, hepatopancreas and from the watery refuse gathering inside polyethylene bag ("juice" fraction). SSOs were grown on Marine Agar 1% (w/v) (Marine Broth, Millipore, supplemented with 1% w/v agar) and incubated for 1-2 days at 20°C. Single colonies were picked, purified and identified using MALDI-TOF (Autof ms1000).

Phages against selected SSOs were isolated from the homogenized langoustine tissue and "juice" fractions. Samples were filtered using 0.22 um pore size filters, and filtrate was used to challenge bacterial host strains in plaque and spot assays. Identified plaques were picked, purified and stored at 4°C for further analysis.

Phage DNA was extracted using phenol:chloroform method (see Rihtman et al. 2016, DOI: 10.7717/peerj.2055) and sequenced using both MinION (Oxford Nanopore Technologies) and Illumina (SeqCenter, Pittsburgh, PA) platforms. Phage genomes were assembled de novo and compared against reference sequences using ViPTree and TaxMyPhage (Millard et al. 2025, DOI: 10.1089/phage.2024.0050) to determine their relatedness and novelty.

Virion morphology was determined by transmission electron microscopy (TEM) at the Advanced Microscopy Facility, University of Leicester using JEOL 2100 TEM.

Volatile organic compounds (VOCs) composition of the langoustine samples was determined by transferring organic material to 10 mL glass bottles followed by 1 hour incubation at 25°C to equalize the concentration of VOCs and subsequent Headspace Solid-Phase Microextraction Gas Chromatography Mass Spectrometry (HS-SPME-GC-MS).

Preliminary phage trials were performed using 1-day old langoustines, langoustine tails and dissected abdominal flexor muscles. These were submerged in phage cocktails (mixture of selected phages normalized to ~107 pfu/mL) for 5 min and stored on ice. VOC composition of the samples was measured on day 1 and day 7. The changes in VOC compared to the untreated control samples were used to determine the most effective phage cocktail.

The degradation study using selected phage cocktail was performed using 108 freshly caught langoustines, divided into two groups: treatment and control, and sampled over 11 days, as described above. The changes in selected VOCs and microbiome composition (via 16S rRNA gene sequencing) were measured and compared between the treatment groups.

Results:
We have isolated and characterised over 40 phages against common SSOs: Pseudoalteromonas spp. and Psychrobacter spp. Phages varied from the most common tailed phages (class: Caudoviricetes), through filamentous phages (family: Inoviridae) to rare, enveloped phages (family: Corticoviridae), giving us a range of tools for the biocontrol of SSOs.

Preliminary trials showed that phage cocktails could alter the composition of VOCs of the samples, with the cocktail consisting of 5 phages outperforming the cocktail formed out of 13 different phages.

The degradation study using fine-tuned phage cocktail showed a reduction in VOCs of interest such as trimethylamine (TMA; N,N-dimethyl-methylamine) and dimethyl sulphide over 7 days. The number of bacterial total viable counts (TVCs), microbial diversity and abundance of Pseudoalteromonas spp. were visibly reduced after the phage treatment in both “juice” fraction and muscle tissue over 8 days.

Discussion and conclusions:
In this study, we have isolated and characterised a range of novel phages against the most prevalent Nephrops norvegicus SSOs. Subsequently, we determined that phage cocktails containing these phages can influence the VOCs composition of langoustine samples. Finally, we have performed an 11-day long degradation trial on freshly caught langoustines which showed, that phage cocktail can reduce the bacterial load and diversity in the samples simultaneously reducing the accumulation of TMA and dimethyl disulphide, a common malodour causing metabolites.

Our research can be directly translated into reduction of the food waste, decreasing the resultant revenue losses thus increasing the sustainability of the fishing industry. Isolated phages alongside the newly developed methods can also be used for the extension of the shelf-life of other perishable products such as fish or meat. Further studies will determine the exact product type, its formulation parameters and the most effective delivery method.

A new approach to extract multifunctional seaweed protein ingredients rich in vitamin B12 and polyunsaturated fatty acids

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Abstract

Alternative protein sources such as seaweed can help relieve the pressure on land-based protein supply. Besides being relatively protein-rich, the adaptable green species Ulva fenestrata (sea lettuce) is rich in vitamin B12 and its fatty acids are predominantly polyunsaturated omega-3 and -6. Hereby, it constitutes a promising raw material for the production of new food protein ingredients. However, the development of industrial processes to extract protein from seaweed is still in its infancy due to low extraction yields. Based on our experience and literature analysis, current extraction methods primarily target water-soluble proteins, while the insoluble ones - mainly located in the thylakoid membranes - remain overlooked. Here we hypothesized that a new surfactant-based method targeting both protein fractions would achieve higher yields.

In the extractions, fresh U. fenestrata was blended with an aqueous solution containing a surfactant after which the seaweed pellet was reprocessed with an alkaline aqueous solution. The solubilized proteins were then precipitated via acidification and dewatered. Extraction yields were calculated via total amino acid analysis (LC-MS). Different microscopy tools and SDS-PAGE were used to determine the microstructure of the seaweed pellets and the polypeptides of the solubilized protein, respectively. Individual fatty acids were determined by GC-MS and biologically active vitamin B12 by LC-MS/MS.

The new method provided a 3.4-fold increase in total protein extraction yields compared to two alkaline extraction cycles alone. Both microstructure and SDS-PAGE tests indicated that the surfactant indeed targeted proteins embedded within the thylakoids. In parallel, we hypothesized that co-extracted membrane lipids likely played a role in facilitating protein precipitation. The resulting dried ingredients contained >50% protein, high amounts of vitamin B12 (130µg/100g dw), and ~2% polyunsaturated fatty acids, emphasizing their multifunctionality as food ingredients.

In conclusion, this proof-of-concept study developed a more efficient protein extraction method for seaweed than state-of-the art approaches. In the long run, it can contribute to the rising global need for more sustainable food protein, but also for other valuable seaweed-derived molecules partitioning into the ingredient, or being recovered from the extraction side streams in a cascading approach.

References:

Trigo, J.P., Steinhagen, S., Stedt, K., Krona, A., Verhagen, S., Pavia, H., Abdollahi, M. and Undeland, I., 2025. A new method for protein extraction from sea lettuce (Ulva fenestrata) via surfactants and alkaline aqueous solutions. Food Chemistry, 464, p.141839.

Trigo, J.P., Chamlagain, B., Thorén, J., Strand, R., Juanola, M.V.L., Steinhagen, S., Kinnby, A., Toth, G., Kariluoto, S. and Undeland, I., 2025. Sea lettuce (Ulva fenestrata) as a rich source of cobalamin (vitamin B12)–both as processed whole biomass and as an extracted protein ingredient. Food Chemistry, 483, p.144302.

Quality of pelagic side-streams

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Abstract

Introduction

To meet the growing demands of global food security, sustainability, and resource efficiency, it is essential to improve the utilization of seafood resources. Recent advances in biotechnology and processing technologies have unlocked the potential of underutilized seafood side-streams, upcycling these into high-value applications across various sectors. A critical prerequisite for this valorization is stable raw material of high quality, as variability in composition, and quality can significantly impact processing efficiency, product functionality.

This study aimed to map nutritional and chemical quality as well as oxidative and autolytic stability of various herring side-streams sampled throughout one season, to support the development of a quality flow analysis for improved resource utilization.

Methods

Different fractions of side-streams (heads, backbone, viscera, belly flap and skin) were collected from processing of small and large Norwegian spring-spawning herring caught between September and January 2024-2025. Analyses of proximate composition as well as fatty acid and amino acid composition were conducted. Oxidation markers, such as peroxide values and anisidine values were measured as well as markers of autolysis. Data on quantity of the side streams were combined with data on selected quality parameters to form a quality flow analysis.

Results and discussion

The belly flap and skin fractions exhibited the highest lipid content, approximately 40% and 25 %, respectively. In belly flaps, the lipid content was reduced from August to January. All other fractions comprised between 10-15% lipids. Protein content was around 15 % across all fractions except for belly

flaps and viscera, which showed lower levels. All fractions also contained high quality protein. Further, substantial amounts of eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and cetoleic acid were detected.
Oxidation levels were generally low across all fractions; however, head and viscera showed elevated oxidation markers compared to other parts. This suggests that blood content plays a more significant role in oxidative stability than lipid content alone. This work has contributed with more data into the quality flow analysis of side-streams from pelagic fish.

Conclusion
Small seasonal and size variations were observed, while differences between fractions should be acknowledged, which could improve material allocation and thus enhance the utilization of pelagic side-streams.

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Blue resources for functional foods: innovation and evidence-based insights on the valorization of aquatic biodiversity for health and well-being

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Abstract

INTRODUCTION

Aquatic ecosystems represent a vast and underexploited reservoir of bioactive compounds with high potential for functional food development. The strategic valorization of blue resources—including marine organisms, algae, and aquatic by-products—provides an opportunity to enhance human health and contribute to disease prevention, owing to their content of essential nutrients such as omega-3 polyunsaturated fatty acids (PUFA), namely eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), iodine, selenium, and other compounds. Functional foods are defined as foods that, beyond meeting basic nutritional requirements, deliver scientifically substantiated health benefits, including the promotion of physiological functions and the reduction of chronic disease risk. The development of functional foods incorporating marine-derived bioactives offers a promising strategy to address nutrient deficiencies—such as insufficient dietary intake of iodine and omega-3 fatty acids—prevalent in many populations. To fully harness this potential, it is crucial to apply a multidisciplinary approach that includes studies on technological processing, nutritional profiling, compound bioaccessibility, bioactivity, and safety, thereby ensuring both efficacy for the consumer and sustainable resource utilization in alignment with circular bioeconomy principles.

AIM RESEARCH

This study presents evidence-based insights into the valorization of aquatic biodiversity for functional foods, highlighting the holistic research approach required to innovate and develop products that

deliver health benefits beyond basic nutrition. As examples, seaweeds-based nachos and a fish-based sauce, using Gracilaria gracilis (red seaweeds) and Atlantic chub mackerel (Scomber colias) as functional ingredients, were developed through integrated technological, nutritional, and bioactivity assessments to support health promotion and disease risk reduction.

MATERIAL/METHODS/DESIGN

The red seaweed Gracilaria gracilis was cultivated in an Integrated Multi-Trophic Aquaculture, at the AQUALVOR Lda., located in Lagos (Portugal) and was harvested in April 2024. Mackerel was caught off in Portuguese waters in April 2025. The food prototype product enriched with G. gracilis and mackerel was designed for younger consumers (encompassing children, teenagers, and young adults) as a healthy snack gluten-free Nachos and Sauce chickpea-based hummus. Compound analysis (fatty acids, essential elements, etc.), compounds' bioaccessibility (through the in vitro simulation of the human digestive process in the mouth, stomach, and small intestine), and bioactivities (antioxidant, anti-inflammatory) followed methods described by Cardoso et al. (2024) and Pacheco et al. (2025). Culinary treatments (boiling, roasting) reflected typical food preparation. Data were used to evaluate the risk-benefit as described by Afonso et al. (2019) and guide the nutritional formulation of functional product prototypes. Particularly, risk-benefit assessment used advanced mathematical-statistical modeling along with hazards (as methylmercury and arsenic) and benefits (as omega-3 PUFA and I) data (including bioaccessible levels), sourced from IPMA (or scientific articles), from selected matrices, such as fish and seaweed species. Daily/weekly consumption scenarios, portions and reference thresholds, like the European Food Safety Authority (EFSA) Dietary Reference Values and Tolerable Weekly Intakes (TWI) or other reference values, were considered.

RESULTS AND DISCUSSION

The nutritional characterization of the raw materials — seaweed and fish — revealed noteworthy levels of bioactive compounds, including polyphenols and iodine in seaweed, as well as omega-3 fatty acids, particularly EPA and DHA, and selenium in fish. Both matrices exhibited antioxidant and anti-inflammatory activities, as well as low levels (below thresholds) of contaminants, such as methylmercury in fish and arsenic in algae. In the development of functional products, priority was given to bioactive compounds that occur in substantial amounts within these marine matrices, which are well-established as natural dietary sources of such essential/important nutrients. Particular attention was given to iodine from G. gracilis and EPA+DHA from mackerel, given their widespread scarceness in Western diet despite well-documented roles in supporting metabolic, neurological, and cardiovascular health as well as their importance in promoting a balanced, health-enhancing diet. The risk-benefit assessment associated with the consumption of these ingredients was a key element in guiding the development process and formulation optimization, thereby ensuring the nutritional and safety requirements of the final functional food products.

The final seaweed-based nacho formulation incorporated approximately 1% (w/w) freeze-dried G. gracilis biomass, containing ~100 µg of iodine per gram of dry weight, designed to deliver an iodine intake consistent with EFSA's recommended adequate intake (90–150 µg/day) while remaining below the established upper limit (250–900 µg/day, depending on age group), through a typical portion of approximately 30 nachos (5 g/nacho per unit). Additionally, the inclusion of 6% boiled mackerel in the

sauce ensured EPA+DHA levels met the EFSA adequate intake recommendation of 250 mg/day, with bioaccessibility exceeding 70%, further supporting the neuroprotective potential of the final product as reported in relevant scientific literature.

CONCLUSION(S)

The highly innovative combined incorporation of G. gracilis and mackerel into the formulated products has made it possible to develop affordable, tasteful, sustainable, and healthy food, the consumption of which brings added benefits for health and well-being through its invaluable marine nutrients and biological activities.

REFERENCES

Cardoso et al. (2024), http://dx.doi.org/10.3390/foods13091;
Pacheco et al (2025), https://doi.org/10.1007/s10811-025-03529-6;
Afonso et al (2019), https://doi.org/10.1080/09637486.2018.1551334

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Improving the nutritional and sensory quality of baguette bread with functional ingredients from fish by-products hydrolysates

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Abstract

AIM OF RESEARCH

This study aimed to investigate the effects of substituting wheat flour with fish protein hydrolysates (FPH) derived from sea bass (D. labrax) and salmon (S. salar) by-products in bread making. The objectives included enhancing the bread's nutritional value, evaluating sensory qualities, and assessing physicochemical changes. By using fish by-products, which represent 30–50% of total fish weight and are frequently discarded, this research contributes to sustainable food production and advances circular economy principles within the fishing industry. The study sought to identify optimal FPH substitution levels that maximize nutritional enrichment, particularly by increasing protein content, main source of essential amino acids and bioactive peptides, while maintaining acceptable sensory and textural properties. This approach offers a novel pathway for developing functional bakery products with added health benefits.

MATERIALS & METHODS

Functional ingredients consisted of FPH produced from sea bass and salmon heads (by-products) applying enzymatic hydrolysis based on a combination of Protamex®, Protana Prime® and Protana UBoost® enzymes. This enzyme combination had previously demonstrated the best sensory behavior. Five bread formulations were developed: a control (100% refined wheat flour) and four FPH-substituted breads (SB-2.5: 2.5% sea bass FPH; SB-5: 5% sea bass FPH; S-2.5: 2.5% salmon FPH; S-5: 5% salmon FPH). Proximate composition (moisture, protein, fat, ash) was analyzed following standard protocols. Physicochemical properties included texture profile analysis (TPA) for crumb, puncture tests for crust hardness and fracturability, digital image analysis for alveolar structure, and scanning electron

microscopy for crumb microstructure. Color was assessed using CIEL*a*b* color space in both crumb and crust. Sensory characterization was performed by a panel of 10 trained assessors (ISO 8586:2023) in a controlled tasting room (ISO 8589:2007), using a modified flash profiling technique to develop a sensory lexicon and evaluate attributes related to visual, aromatic, taste, and texture parameters of crumb and crust. Statistical analyses involved two-way ANOVA with interaction, Fisher's multiple comparison test, bilateral Dunnett's test for color differences, and generalized procrustean analysis (GPA) with multifactorial analysis (MFA) for sensory data ($p < 0.05$), using Microsoft Excel and XLSTAT® software.

RESULTS AND DISCUSSION

FPH incorporation significantly enhanced the nutritional profile of bread, with protein of high biological value content increasing by approximately 1.5% ($p < 0.05$) due to FPH addition (sea bass FPH: 48.33% protein; salmon FPH: 48.66% protein), potentially allowing labeling as a protein source food. This also suggests the presence of bioactive peptides in FPH which could be related to health-promoting properties, such as anti-inflammatory, neuroprotective, and hepatoprotective effects. Moisture content in bread increased due to the hydrophilic nature of FPH peptides (-NH2 and -COOH groups), with values ranging from 24.96% in control to 28.86% in S-5 treatment. Ash content rose, indicating increased mineral content, while carbohydrate content slightly decreased, and fat content showed minor variations. Textural analysis revealed increased hardness in FPH breads, particularly at 5% substitution, attributed to peptides disrupting gluten-starch interactions, as evidenced by SEM showing larger alveolar structures and thinner cell walls at higher FPH levels. Crust color analysis indicated reduced redness (a*) and yellowness (b*) in FPH breads ($p < 0.05$), due to higher moisture content slowing down caramelization and Maillard reactions during baking. Crumb color showed minimal differences, with slight variations linked to the inherent FPH color. Sensory evaluation revealed that 2.5% FPH breads exhibited desirable attributes, including uniform toasting, pleasant aroma, and subtle umami notes, enhancing sensory complexity without compromising its quality. In contrast, 5% FPH breads displayed undesirable sensory characteristics, such as bitter taste, rancid smell, and fishy odor. SEM and TPA confirmed a threshold effect at 5% FPH, from this a gluten integrity was affected, leading to larger crumb cavities and reduced hardness compared to 2.5% FPH.

CONCLUSIONS

The incorporation of fish protein hydrolysates from sea bass and salmon by-products into bread significantly enhanced nutritional value by increasing high biological value protein content and introducing bioactive peptides with potential health benefits. A substitution level of 2.5% FPH maintains favorable sensory and textural properties, making it a practical option for developing functional bakery products that align with consumer preferences. However, higher substitution levels (5%) result in adverse sensory attributes (bitter taste, fishy odor) and textural changes (increased hardness, larger alveoli), which may limit market acceptance. These findings highlight the potential of FPH as a sustainable ingredient, repurposing fish by-products to support circular economy strategies and reduce waste in the fishing industry. Future research should explore strategies to mitigate sensory and textural challenges at higher FPH levels, such as incorporating flavor-masking agents, texture-modifying ingredients, or

advanced processing techniques like microencapsulation. Additionally, further studies are required to quantify the bioactive peptide content and validate their health benefits in vivo, paving the way for commercially viable, nutritionally enriched, and environmentally sustainable bakery products.

Biocontrol of *Listeria monocytogenes* in Ready-to-Eat Atlantic salmon using lactic acid bacteria: safety assessment and antilisterial effects

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Abstract

Listeria monocytogenes (Lm) presents a significant food safety challenge, with recent multinational outbreaks of listeriosis linked to ready-to-eat (RTE) salmon products. Despite extensive industry efforts, Lm's ability to proliferate during cold storage in RTE salmon remains a concern. In this context, biopreservation using lactic acid bacteria (LAB) offers a promising strategy to inhibit Lm growth and improve product safety. For LAB strains to be used in food applications, they must be proven safe and exhibit consistent antimicrobial activity. This study aimed to evaluate the safety profiles and antilisterial effects of previously characterised LAB strains, using both model systems and salmon matrices.

Ten LAB isolates, belonging to the genera Leuconostoc and Carnobacterium, were characterised for genotypic and phenotypic traits related to safety and antimicrobial activity using whole genome sequencing (WGS). No acquired antimicrobial resistance genes were detected in any of the strains. However, phenotypic resistance was observed among Leuconostoc and Carnobacterium species to vancomycin (80%), ceftriaxone (100%), clindamycin (30%), and penicillin/rifampin (10%). Additionally, no virulence-associated genes were identified. Six LAB strains demonstrated potential to produce class I and II bacteriocins, supported by the presence of gene clusters associated with bacteriocin synthesis. Four of these strains were further evaluated to assess how media composition (salmon juice, BHI, and ¼

BHI) and pH level (6.4 and 7.6) affected their antimicrobial activity against three L. monocytogenes strains. The most substantial antilisterial effect was observed in salmon juice with pH 6.4 ($P < 0.05$). The antilisterial of three of the four strains was also validated in vacuum-packed salmon stored at 4 °C. Co-inoculation with a mixture of three L. monocytogenes strains resulted in a significant reduction in pathogen growth over a 16-day storage period ($P < 0.05$).

Overall, the absence of antibiotic resistance and virulence genes, combined with demonstrated antilisterial activity both in vitro and in real salmon systems, highlights the potential of these LAB strains for use in salmon biopreservation. However, observed discrepancies between phenotypic and genotypic antibiotic resistance profiles warrant further investigations.

Seafood spoilage/freshness determination: from the lab analysis to intelligent management systems

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Abstract

Fresh or lightly preserved fish is very perishable and spoils mainly due to bacterial growth and metabolic activity. Fish spoilage is determined by (i) the diversity and population size of the initial spoilage microbiota (which is directly related to the fish geographical origin and the contamination after catch) and (ii) the storage conditions (mostly temperature and gaseous atmosphere). Such factors are responsible for the selection of the dominant final microbiota, the so-called Specific Spoilage Organisms (SSO) affecting both its growth rate and metabolic products. Fish become spoiled when the spoilage microbiota reaches a considerable population level which is responsible for the accumulation of microbial metabolites with unpleasant odors/flavors. The knowledge of the microbial spoilage population or the concentration of the spoilage metabolites can give us the spoilage/freshness status. To evaluate quality/freshness, microbiological analysis or chemical analysis are required. However, classical microbiological analysis is laborious and retrospective. To overcome such drawbacks, the determination of total microbial population can be carried out via quantitative PCR (Ct – logs) using bacterial DNA directly from the fish flesh. This approach can give freshness/spoilage status within 5 hours. On the other hand, chemical determination of spoilage indices can be alternatively applied giving results faster than q-PCR. Although these approaches could be effective, fish industry and food authorities require even faster and cost-effective methods to ensure safety and quality of seafood. In this direction, there is another option based on the monitoring of the total profile of chemical changes occurred in the product. This approach makes use of portable sensors based on Fourier transform infrared (FTIR) spectroscopy or Multispectral imaging (MSI) with the advantage of giving information within seconds. The spatial and spectral information can be combined with partial least squares regression (PLS-R) analysis and finally evaluate fish spoilage. Again the PLS-R models have to be derived

for each product after taking as many samples to give a reliable correlation of spectral changes against microbial spoilage population or other spoilage/freshness indices. This approach can be combined with digital technologies and IT advances, such as machine learning and AI. In this respect the collected spectral data can be loaded in a cloud platform, processed and the outcome information shared across the seafood value chain providing an intelligent seafood quality/freshness management tool. Furthermore, using this technology, other type of information such as authenticity and traceability aspects of the product can also be shared to provide transparency in the seafood value chain and increase consumer trust and acceptance of the seafood products.

Antibiotic-resistant versus antibiotic-susceptible pathogens in mussels and their farming water

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Abstract

Aim

Facing two of the greatest challenges of our century, climate change and antimicrobial resistance (AMR), the scientific community has turned its interest to prevent or control their consequences for the protection of the environment, the economy and public health. Aquatic ecosystems constitute the largest habitat of microorganisms on Earth, hosting bacteria that cause infections in humans, including pathogens such as Escherichia coli, Enterococcus faecium, Enterococcus faecalis, etc., which are entered there from land (e.g. cities, hospitals, animal farms, industries, farms, pastures) through runoff or drainage, contaminating the aquatic environment and fish. Among seafood, shellfish have been found to be responsible for the largest percentage of food poisoning from such pathogens worldwide. In recent years, it has been observed that such pathogens from the aquatic environment and fish are increasingly resistant to antibiotics used to treat humans and animals. Despite this serious fact, scientific questions such as 'do antibiotic-resistant foodborne pathogens dominate or not over susceptible pathogens in mussels and their culture water?', 'what contamination sources of land do they come from?' and 'what is the fate of antibiotic-resistant pathogens vs susceptible ones in mussel cultures?', have not been answered in Greece so far.

Material /Methods / Design

Mussels, water and sludge samples were collected from Thermaic Gulf (Thessaloniki, Greece) and the surrounding environment (mussel farms, waste treatment processing plants, river estuaries, animal farms, agricultural crops, etc.). The samples were analyzed by classical microbiological analysis for the

enumeration of various microorganisms (spoilers, beneficials and pathogens) and the isolation of foodborne pathogens, as well as microorganisms with potential beneficial properties such as lactic acid bacteria. In particular, ~50% of the colonies grown on selective media, mainly for pathogens and beneficials growth, were isolated for identification. For each of them, DNA was extracted using Macherey-Nagel, NucleoSpin® Tissue kit, following manufacturer's instructions. The isolates were first grouped via High Resolution Melting (HRM) analysis and then representative isolates of each group were analyzed by 16S rRNA Sanger Sequencing. Freshly cultures (18-24 h) were tested for their antibiotic resistance via the Disk Diffusion method. The antibiotics tested in this work have been chosen based on their use in human therapy (e.g. streptomycin, ampicillin, penicillin G). Strains were characterized as sensitive and resistant based on their inhibition zones (mm). The selected strains (resistant and sensitive strains of the same species to specific antibiotics) such as Escherichia coli, Enterococcus faecium and Enterococcus faecalis were studied in vitro to determine the population changes (experimental values) and estimate their kinetics (initial population, maximum population, maximum specific growth rate, lag phase, etc.) at three different temperatures (12, 22, 30°C). To allow the estimation, comparison and evaluation of growth characteristics of the antibiotic resistant and sensitive strains under these temperatures, the population changes were fitted using Baranyi equation. DMFIT software (Institute of Food Research, Reading, UK) was used for fitting and growth rate estimation.

Results and Discussion

The sources of microbial contamination in the Thermaic Gulf area where the mussel farms are located were highlighted. The pumphouses were found to be the main source of contamination of the mussel farm and their culture waters. The waste treatment processing plant was found to be the main source of transfer Escherichia coli in mussels and their culture waters. Escherichia coli, Enterococcus faecalis and Enterococcus faecium were the main foodborne pathogens almost in all samples. Many other potential pathogens were detected, including Klebsiela oxytoca, Serratia marcescens, Shingella flexneri, Citrobacter freundii etc. in samples including mussels, while Enterococcus faecium, Enterococcus faecalis and Enterococcus casseliflavus were found only in environmental samples and not in mussels. Regarding antibiotic resistance, foodborne pathogenic bacteria found to be resistant to Clindamycin, Vancomycin, Nalidixic acid, Penicillin and Sulfonamides, while they were sensitive to Kanamycin, Gentamicin, Ciprofloxacin, Oxytetracycline and Azithromycin (highest inhibition). The kinetics of both antibiotic resistant and sensitive strains presented differences depending on the temperature.

Conclusions

The findings will answer to what extent the introduction of AMR foodborne pathogens, from the land to the aquatic environment, can affect the contamination of farming water (natural environment) and safety of mussels (food safety), whether this constitutes a problem for the sustainability of mussel farms in Greece and a threat to public health, and how such a problem could be controlled, so that we can propose preventive measures (e.g. intelligent monitoring tools) or even to address such challenges (e.g. use of probiotics).

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Seasonal variation in the microbial communities of the Green Crab

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Abstract

The rise in population of green crab in the Danish coast has become a threat to the local fishery. Their feeding behaviour and disruptive activity towards eelgrass meadows endangers biodiversity. Underutilized by the local economy we are investigating its potential to become a resource for human nutrition, starting from its microbiota. In this study four seasonal samples (K1 to K4) of green crabs (Carcinus maenas) were caught at 3 months intervals off the Lillebælt (DK) a coastal area in a period between 2023-2024. To characterize the crab's microbial composition and its seasonal shifts a selection of media was used to determine Total aerobic count, Bacillus spp., Enterobacteriaceae, lactic acid bacteria, Fungi, Salmonella spp., Listeria monocytogenes and Bacillus cereus. Isolates from each media were identified by MALDI-TOF. Results from the culture dependent approach were compared to NGS 16s RNA to scrutinize any changes in the microbial community over the year. Of the pathogenic bacteria inspected in this study only B. cereus is present at all time points, no statistically significant shifts in abundance were observed. When considered as half seasons, comparing summer/autumn to winter/spring showed significant differences ($p = 0.00002$) in the microbial composition. The present study provides new insights into the green crab's microbiota, highlighting which challenges future product development must consider when designing new products.

SESSION 4 - F405

" Detect, control, save — innovative food safety technologies for the fish industry "

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Abstract

This presentation explores the intersection of regulatory change, food safety, and technological innovation, focusing on the control of Listeria monocytogenes in ready-to-eat (RTE) food products. It addresses the implications of the newly published EU Regulation 2024/2895, which introduces stricter microbiological criteria for Listeria in RTE foods. Unlike the previous standard—requiring absence of Listeria in 25g of product at the time of dispatch—the new regulation mandates that producers ensure compliance with safety thresholds throughout the entire shelf life of the product. This change, effective from July 1, 2026, presents significant challenges for food manufacturers, particularly in the fish industry, where products like smoked salmon are at high risk.

The presentation outlines the financial and reputational risks associated with Listeria contamination, including costs related to product recalls, production downtime, sanitation, and potential brand damage. Real-world case studies from Poland, Denmark, Belgium, and the U.S. illustrate the scale of these risks, with some incidents resulting in losses exceeding €30 million and multiple fatalities.

To mitigate these risks, the presentation introduces a suite of advanced diagnostic and monitoring technologies offered by bioMérieux. These include:

- GENE-UP® Typer: A rapid, unique on the market, in-house PCR-based tool for strain typing of pathogens, delivering results within 24 hours.
- Pathogen Mapping: A genomic approach to trace contamination sources within production facilities.
- WGS (Whole Genome Sequencing) and ENVIROMAP®: Tools for environmental monitoring, strain tracking, and data-driven decision-making.

These technologies enable producers to identify contamination sources, assess the risk of pathogen growth, and implement targeted interventions. The presentation emphasizes the importance of proactive contamination control over reactive crisis management and demonstrates how data analytics and genomic expertise can transform food safety strategies.

The session concludes with testimonials from industry users who have implemented these solutions, reporting improved quality control, reduced operational costs, and enhanced regulatory compliance. The overarching message is clear: modern microbiological technologies are not only essential for

meeting new legal requirements but also for safeguarding public health and protecting brand integrity in an increasingly regulated and risk-sensitive food industry.

Endolysins as a therapy for prevention of salmon associated pasteurellosis

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Abstract

Bacteriophages, known as phages, are viruses that infect and replicate within bacteria. Abundant in all environments, they can be isolated and harnessed as antibacterials, which are highly specific, and represent an alternative to antibiotics. Although ubiquitous in nature, there are bacteria for which phages have not yet been isolated against. Analysis of bacterial genomes shows us that prophages (phage genomes integrated within a host bacterium as part of a lysogenic life cycle) are common and carry the genes needed for cell lysis, known as endolysins. Endolysins are hydrolytic enzymes which cleave the cell wall, allowing the virions to be released after the lytic cycle is activated. Endolysins have been shown to have therapeutic potential against bacterial infections, even without the associated phage.

Pasteurellosis is an emerging disease in salmon aquaculture, with observable symptoms such as bleeding, necrosis and endocarditis. First observed in Scotland, recent outbreaks have been identified in Norwegian salmon farms. While no phage has yet been isolated against the causative Phocoenobacter spp. bacteria, genomic analysis has revealed an unusually large number of phage defence systems, including restriction modification systems and CRISPR-Cas systems.

In this study we seek to identify prophages in Phocoenobacter genomes and endolysins encoded by them. We will then sought to express the endolysins and assess their efficacy against Phocoenobacter spp.

Materials and methods:

Sequence analysis

Phocoenobacter genomes were obtained from NCBI. Prophage sequences were identified using

PHASTEST, extracted and annotated using Pharokka. Putative endolysin sequences were obtained and duplicates removed.

Endolysin synthesis and cloning

Endolysins PE1-6 were codon optimised for E. coli, synthesised and cloned into pET-IDT plasmid vector by Integrated DNA Technologies (IDT). Subsequently, endolysin genes were subcloned into pLEICS-04 vector, which contains a N-terminal GST tag for purification. Plasmids were transformed into E. coli BL21 cells for expression.

Protein expression and purification

Cultures were grown in 2xYT media, supplemented with 100 µg/ml kanamycin and incubated at 37°C with shaking. When the OD600 reached 0.5-0.6, cultures were induced with isopropyl-β-D-1-thiogalactopyranoside (IPTG) at final concentration of 0.1 mM. Induced cultures were incubated overnight at 20°C with shaking. Lysates were purified with GST resin and the tag was cleaved off using a TEV protease.

Results

Although twelve putative endolysins were identified initially, after removal of duplicates, this was reduced to six unique endolysis. These six endolysins were located on six unique prophages belonging to five different Phocoenobacter genomes. Initially, endolysin sequences have been expressed using pET-IDT vector resulting in four endolysins being successfully expressed. However, all of these proteins were restricted to the insoluble fraction. Efforts to increase solubility, which involved fusing solubility tags to the proteins, have resulted in three soluble endolysins in pilot experiments. Ongoing work will seek to purify and test the endolysins against Phocoenobacter, initially by spotting onto bacterial plates to test sensitivity, followed by killing assays.

Discussion

Bacteriophages as a bacterial control method in aquaculture have potential to be an effective, targeted treatment which can provide an answer to the antimicrobial resistance problem. In cases where phage has not yet been isolated, such as the anti-phage defence-heavy Phocoenobacter sp., endolysins may offer the same advantages without the need for a lab propagated phage. In this study we have identified prophages within Phocoenobacter genomes and synthesised several endolysins located on the prophages. Ongoing work will test the efficacy of the endolysins against the bacteria and seek to overcome challenges in solubility and outer membrane permeability of Gram-negative bacteria. This study aims to provide an effective therapy for pasteurellosis in salmon farms and highlight the potential for endolysins in animal disease control.

Beyond 60 °C: validating thermal safety against anisakis in traditional cooking

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Abstract

Aim research

Anisakiasis is a human infection caused by consuming raw or undercooked fish containing viable third-stage Anisakis larvae. To prevent it, the EU regulations and the European Food Safety Authority (EFSA) recommend cooking fish that has not been frozen or processed in conditions that kill the parasite to an internal temperature of 60 °C or higher for at least one minute. However, reaching this temperature in the fish thermal centre can lead to undesirable changes in its quality, especially in large specimens. Recent studies suggest that Anisakis larvae mortality depends not only on the maximum temperature reached during cooking, but also on the thermal history experienced. In this context, within the framework of the HEATSAKIS project, we developed a thermal inactivation model capable of predicting parasite viability as a function of time and temperature exposure, in both static and dynamic conditions, and we successfully validated it on isolated larvae in lab conditions. Now, it is time to (1) validate the model in infected fish at real cooking conditions such as those occurring during oven-cooking and, once validated, (2) use the model to assess the risk of Anisakis infection in traditional oven-cooked fish recipes.

Material and methods

(1) To validate the inactivation model in infected fish at real cooking conditions, 8 hake fillets infected with 96 Anisakis L3 were thermally treated in an oven until the slowest heating point reached 50 °C. To test the model at different cooking conditions, four oven temperatures (120 °C, 160 °C, 180 °C, and 200 °C) and two cooling rates (fast and slow) were assayed to achieve very different thermal histories that presumably represented both safe and unsafe conditions.

(2) To evaluate the risk of Anisakis infection in fish cooked according to traditional recipes, 12 thin

(approx. 20 mm thick) and 12 thick (approx. 35 mm thick) pieces of hake, each infected with 30 L3, were oven-cooked at a fixed temperature of 180 ºC for 8 minutes and 12 minutes, respectively. These cooking conditions were chosen based on common fish recipes.
During both sets of experiments, temperature was recorded at different fish locations. From these data, model predictions were made and compared to visually observed larval survival.

Results and Discussion
The results showed excellent agreement between the predicted and experimental viability values, confirming the effectiveness of the model in predicting the thermal inactivation of Anisakis larvae in fish. The thermal profiles recorded in fish cooked according to traditional recipes showed that EFSA recommended temperature-time conditions (≥60 ºC for ≥1 min) were not always achieved. However, according to the validated model and the visual examination, all the fish recipes studied were safe in terms of larval inactivation, even without achieving these EFSA conditions.

Conclusions
The Anisakis survival model demonstrated strong predictive capability in infected fish. Future steps should involve integrating this knowledge to develop cooking methods that are not only safe, but also preserve optimal organoleptic characteristics.

Acknowledgements
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Keywords
Anisakis, heat inactivation, hake, survival model

Management of Portuguese shellfish mainland production areas classified in 2024

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Abstract

MANAGEMENT OF PORTUGUESE SHELLFISH MAINLAND PRODUCTION AREAS CLASSIFIED IN 2024

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INTRODUCTION

Bivalves, such as clams, mussels and oysters, have been a staple in human diets since ancient times, having a superior nutrient value of vitamin B12, omega-3 fatty acids, choline, iron, selenium and zinc, when compared to land-based protein sources. However, as filter feeders, they can accumulate microorganisms and chemical contaminants from the water, posing health risks to consumers. Therefore, uniform official controls at the primary production are crucial in order to ensure a high level of consumer protection.

At European level, EU legislation requires comprehensive official controls to be carried out by competent authorities. EU Regulation 2017/625 requires that competent authorities classify bivalve production and relay areas, whereas EC Regulation 853/2004 notes that producers can only harvest bivalves for commercial sale from classified areas. EC Regulation 2019/627 specifies the rules for the official controls on live bivalves.

In Portugal, the National Bivalve Mollusc Monitoring System (SNMB) is an integral part of the mission and attributions of the Portuguese Institute for the Sea and Atmosphere (IPMA, I.P.), which is responsible for: i) Classification the production areas (ZDP) of live bivalve molluscs; ii) Monitoring of the production areas

of bivalves and establishment of sampling plans; and iii) Decision following monitoring, of temporary ban/opening and reclassification/prohibition of the harvesting and marketing of live bivalve molluscs.

AIM

The aim of this work is to present the main hazards associated with the decision following monitoring of closing and/or to reclassification of bivalve mollusc species in the ZDPs of mainland Portugal during 2024.

MATERIAL AND METHODS

Overall 5,754 coastal water and bivalve samples were evaluated according to guidelines and legal limits, using accredited references methods for harmful phytoplankton, marine toxins, chemical contaminants and microbiological contamination.

RESULTS AND DISCUSSION

According to the European Union (EU) food hygiene rules, in order to assess the health status of a species and/or species present in a given bivalve production area, the criteria established in Implementing Regulation (EU) 2019/627 must be applied. Within the scope of the management of the production areas classified by the SNMB, the decision-making following the monitoring of the ZDPs resulted in more than 100 official reports on the harvesting and marketing of live bivalve molluscs, echinoderms, tunicates and marine gastropods. The four main hazards associated with the closure and/or reclassification of the monitored species in the ZDPs included: i) Contamination by lipophilic toxins (DSP), ii) Bloom of harmful phytoplankton, iii) Contamination by amnesic toxins (ASP) and iv) Microbiological contamination.

CONCLUSION

Given the negative impact that these contaminations have for the productive sector, and given the high socioeconomic relevance of the ecosystem services resulting from shellfish production, it is important to define joint strategies to anticipate these occurrences and mitigate their effects.

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Effect of carvacrol on histamine production in canned tuna inoculated with *R. planticola*

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Abstract

Histamine is a key health concern associated with the consumption of canned tuna, given the potential for the occurrence of allergic and anaphylactic reactions in consumers. There are two potential sources of histamine poisoning related to canned tuna. On the one hand, canned tuna may contain high levels of histamine as a result of inadequate handling between the fish caught and processing. On the other hand, canned tuna could be contaminated with histamine-producing bacteria due to inadequate hygiene or practices, or by other foodstuffs or dressing during food preparation and storage. Many species of bacteria have been related to histamine poisoning, including Enterobacter, Klebsiella, Raoultella and Citrobacter spp. The aim of the present work was to evaluate the effect of carvacrol on the growth of Raoultella planticola and its ability to generate histamine in canned tuna. First, to test the effect of carvacrol on R. planticola growth, the Minimum Inhibitory Concentration (MIC) and the Minimum Bactericidal Concentration (MBC) was determined by using the microdilution method. Furthermore, bactericidal power (MBC/MIC ratio) was calculated. Then, canned tuna meat was inoculated with R. planticola and stored at 4 or 10 oC to investigate the effect of carvacrol on bacterial growth and histamine formation. For this purpose, 2 carvacrol concentrations were tested, 0.5% and 1%, and the results obtained were compared with control samples (inoculated and without carvacrol added). This compound demonstrated to be effective in reducing the growth of R. planticola in tuna samples and also in controlling the formation of histamine at both temperatures. This effectiveness was especially evidenced at the highest carvacrol concentration. Therefore, the use of carvacrol as a natural preservative would be an interesting strategy to reduce the presence of biogenic amines in food and, consequently, mitigate their adverse effects.

Total an inorganic arsenic in seafood products commercialised in Portugal

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Abstract

INTRODUCTION

Seafood products are much appreciated in Portugal. However, some contaminant chemical elements as arsenic (As) can occurred in these species due to anthropogenic or natural sources, constituting a hazard to human health. Regarding this element, organic compounds are not considered toxic to humans, however, inorganic compounds of As III and V are toxic. In this context, the EU has already legislated limits for inorganic arsenic (iAs) in some foods but not in seafood products. However, regulation EU 2023/915 is expected to be revised soon, which will probably include some seafood products.

AIM RESEARCH

The aim of this work was to evaluate the occurrence of total and inorganic arsenic in some seafood products.

MATERIAL/METHODS/DESIGN

Fish, cephalopods and crustacean samples analysed in this study were obtained from frozen seafood industry in Portugal. Bivalves were collected in several production areas on the Portuguese mainland within the scope of National Bivalve Mollusc Monitoring System (SNMB) of IPMA. Total As was determined by Inductively Coupled Plasma Mass Spectrometry (ICP-MS), according to the method defined in EN 17851:2023. Inorganic As (iAs) was quantified by HPLC-ICP-MS based on EN 16802:2016.

RESULTS AND DISCUSSION

Bivalve samples revealed total As levels between 1.9 and 4.7 mg/kg, which are considered usual for this type of species. Regarding iAs, fish and cephalopods samples showed always levels below the quantification limit of 0.010 mg/kg. In what concerns crustaceans and bivalves some samples reached mean concentrations of 0.03 and 0.05 mg/kg, respectively, nevertheless these levels can be considered

low.

CONCLUSION(S)

As a general conclusion, it can be stated that seafood products analysed in this study do not present a risk for human consumption, as far as As is concerned, since iAs levels obtained were always very low and in most cases below 0.010 mg/kg. However, it is advisable to obtain more data on this chemical element in products of marine origin in order to make a better assessment. This is important, given that the regulation EU 2023/915 is expected to be revised soon, probably including seafood products.

Keywords: seafood products, total arsenic, inorganic arsenic.

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Fish products in the e-commerce: Quality and labelling

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Abstract

The purchasing of commodities has changed over the last decade, due to the increasing spread of e-commerce which has been boomed since the covid 19 pandemic. For the seafood market, numerous online platforms have been established offering seafood of all categories, both fresh and frozen as well as processed and ready-to-eat products. As a perishable food, seafood trading requires good quality management throughout the production chain particularly regarding the temperature control. Whereas continuous monitoring of the traditional seafood market is carried out by the food control authorities, e-commerce is currently not yet under regular control. Mislabelling and deficiencies in the quality of seafood have been frequently observed in the traditional market. The situation in the e-commerce market regarding seafood is unknown. In the present pilot study fish products were purchased from various online platforms and analysed to obtain an initial overview regarding quality aspects and labelling.

30 fresh or frozen fish products were investigated to assess freshness and quality as well as to authenticate the fish species. To examine the quality, the incoming core temperature of the products was checked, the hygiene status proved, sensory tests were performed and the TVB-N (total volatile base nitrogen) values analysed. Furthermore, the chemical composition of the fish products was analysed to determine the possible addition of foreign water. Species identification was carried out using protein-based methods and the DNA-based method PCR sequencing. All described methods were carried out following established standards.

Whereas the incoming temperatures of the frozen products were sufficient, two of 12 chilled products were delivered with a core temperature of 4.1°C and exceeded the accepted temperature maximum of 2.0°C. However, the microbiological status of these two products was inconspicuous. Two other chilled products showed higher values, but below limits, of colony-forming units/g (CFU/g) of Pseudomonas spp., and in one fillet the microorganism Listeria innocua was detected. The microbiological status of these three products was considered as safe when sufficiently heatedbefore consumption. The TVB-N

values for spoilage indication in fish products were generally inconspicuous. The analysis of the chemical composition revealed that one product had a foreign water addition of 22.1%. This product also showed a jelly-like appearance in the sensory testing and therefore had to be labelled as processed product. The analytical verification of the fish species detected five mislabelled fish products, corresponding to 16.7%. More exotic fish species were particularly affected. Furthermore, in three cases the commercial designation for the fish species was not correct according to the German official list of commercial designations. Overall, the labelling on the website as well as on the packages was often inaccurate, partially indicating only the genus name, but not the species, or listing several genera. Further, the area of origin was frequently either missing or inconclusive. The fishing gear was in many cases not indicated.
To conclude, in this pilot study, fish products from e-commerce had an acceptable quality in most cases. However, two products were found to have higher incoming temperatures, three products had elevated but still acceptable bacterial counts and undeclared added water was found in one product. Deficiencies were observed for the labelling on the websites and on the packages since they were ambiguous and misleading to a high degree. Compared to the last OPSON XI (1) investigations in Germany in 2022 with 6% of incorrectly labelled seafood species in retail, the rate of mislabelled fish species in this study is high at 16.7%. As mentioned before, this rate is mainly based on more exotic fish species, which were not the focus of the OPSON survey. Consumers, who prefer more exotic and high-valued fish species, seem to be more affected by mislabelled fish than others who buy more traditional species. However, the results strongly advice a regular monitoring of fishery products in online retail. In addition, other seafood such as bivalves and cephalopods should be included in the control in order to obtain a more accurate overview of quality and labelling.

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(1)
https://www.bvl.bund.de/DE/Arbeitsbereiche/01_Lebensmittel/03_Verbraucher/16_Food_Fraud/06_OPSON_Operationen/OPSON-XI/OPSON_11_node.html

HRM as a practical and effective tool for the rapid source tracking of foodborne pathogens along the whole fish production chain in aquaculture

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Abstract

Aim

The present study aimed to validate the use of High-Resolution Melting (HRM) analysis as a reliable molecular tool for the rapid source tracking of potential foodborne pathogens along the whole aquaculture production chain, encompassing both pre-fattening and processing stages.

Material/Methods/Design

Samples from aquaculture facilities e.g. farming water, fish feeds, tanks, sinks, equipment (nets, etc.), working surfaces, fish transport boxes, etc., as well as fish samples in harvesting, handling, processing, packaging, storage, etc. were collected from a leading aquaculture industry in Greece. Culture-based microbiological analysis was used to isolate potential foodborne pathogens. Then, the isolates were analyzed via HRM. HRM was used to rapidly screen and group the isolates based on curve profiles (peaks and shape) of the amplicons. Afterwards, representative isolates (presenting similar HRM peaks and shape) from each group were identified by 16S rRNA gene (V3-V4) Sanger sequencing. Taxa classification was applied via BLASTn software (NCBI). Phylogenetic tree was generated via MEGA software and constructed with the neighbor joining algorithm, to reveal closely phylotypes among strains from different spots, indicating the potential spreading of microbes throughout chain production.

Results and Discussion

HRM was found to be a practical and effective tool for the rapid source tracking of foodborne pathogens

along the whole fish production chain in aquaculture, based on the curve profiles (peaks and shape). The microorganisms (amplicons in HRM) were classified into 10 different groups (all the isolates of each group presented similar peak and shape). The Sanger sequencing confirmed that the isolates with similar HRM curve peaks and shape (>95% similar) belonged to the same species. Thus, the 10 groups were identified as 10 different bacterial species: Escherichia coli, Enterococcus faecium, Enterococcus faecalis, Enterococcus gallinarum, Enterococcus hirae, Klebsiella pneumoniae, Serratia marcescens, Serratia nematodiphilia, Providecia rustigianii and Providencia vermicola.
After the grouping and identification of the pathogens, the sequences were used for phylogenetic analysis to reveal closely related phylotypes among the spots. Based on the analysis, similar phylotypes were observed among the samples (surfaces, fish, fish feed, water) from different spots, indicating a clear spread of pathogens along the aquaculture production chain. More specifically, different phylotypes of Morganella morganii, isolated from different spots (fish, surface, etc. from both pre-fattening and processing plant) were found to be very close to each other. Similar findings were also recorded for Serratia spp. and Klebsiella pneumoniae.

Conclusions

The rapid detection of contamination in aquaculture will help to decision making of the rapid control of those parameters in any stage of fish production, in order to ensure food safety along the whole aquaculture chain production. Therefore, this approach will contribute to minimizing aquaculture losses and protecting consumers health and thus creating sustainable and safe seafood systems.

Acknowledgements

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A novel method of pre-treating microalgae biomass, resistant to cell disruption, with Plasma-Activated Water and Pulsed Electric Field for improving the accessibility of cellular compounds therefrom

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Abstract

A Novel Method of Pre-Treating Microalgae Biomass, Resistant to Cell Disruption, with Plasma-Activated Water and Pulsed Electric Field for Improving the Accessibility of Cellular Compounds Therefrom

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Industrial exploitation of cultivated microalgae as feedstock for value-added bioactive compounds (e.g. proteins, lipids, pigments) could be a sustainable future driver for the bioeconomy having commercially sound multi-purpose applications as e.g. aquaculture feed, biofuels or nutraceuticals for medical and health benefits. Current public/private large-scale efforts are directed towards sustainable, safe and cost-effective processing standards, full biomass utilisation and enhanced end-product quality.

Robust microalgal cell wall structures, such as for Chlorella sorokiniana, may lead to inefficient, unsafe and otherwise unsustainable cell wall disruption/extraction processes which, alongside harvesting constraints, stand out as one of the main techno-economic bottlenecks for large-scale microalgal cascade biorefineries. Such a resilient cell outer layer also poses major challenges for the direct utilization of microalgal biomass in aquaculture feed replacing fish meal/oil, due to its limited digestibility as the enzyme's access to the cell nutrients is impaired.

Microalgae, Chlorella sorokiniana, 15 g/100 g cell dry weight, was treated with cold plasma activated

water (PAW) for 1 h with or without subsequent treatment with pulsed electric fields (PEF), charging voltage of 10 kV/cm and specific field strength of 150 kJ/kg. Tap water and tap water adjusted to pH 2.6 similar to PAW was used as control. Protein and pigment (chlorophyll) extraction was measured.

PEF alone did not increase the protein, nor the chlorophyll extraction compared to control, but PAW showed a significant increase in both extracted protein and pigment even at same pH as control, attributed to the reactive oxidative and nitrogen species (RONS) present in PAW. A huge synergic effect was observed for combining PAW with PEF, protein extraction increasing seven-fold and pigment extraction increasing three-fold compared to control. The combined effect could be a novel approach to extract valuable cellular compounds from microalgae with robust cell walls and increase their useability and remove one bottleneck for large-scale microalgal biorefineries.

The Vermetid gastropod *Vermetus triquetrus*: an underexplored marine resource with biomass fractions rich in polyphenols and displaying high antioxidant activity

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Abstract

INTRODUCTION

Vermetids are sessile gastropods that can play an important role in the structure of marine communities in tropical and temperate waters. They can be found living in coral reefs and on intertidal and subtidal rocky shores, reaching extreme abudance in some regions of the world. However, little is known about their metabolism, biochemical composition, and biological activity. These wormsnails have an irregularly uncoiled calcareous shell, cemented to or embedded in the substrate, and are active and passive suspension feeders. They excrete a stycky mucus net, which is suited to capture near-bed small planktonic organisms for food, and can compete and impact other organisms. In the Portuguese shore, the vermetid Vermetus triquetrus is still an underexplored marine resource.

AIM RESEARCH

Having in mind that experimental analytical work concerning V. triquetrus is scarce, this study aimed to determine the total polyphenol content and antioxidant activity, as measured by different techniques,in the visceral mass and in the head-foot part of this gastropod harvested from the Portuguese shore.

MATERIAL/METHODS/DESIGN

A sample of V. triquetrus was collected in the southern Portuguese shore on 19th March 2025. In the laboratory, a careful dissection of each specimen was performed to separate the visceral mass and the head-foot part of the animal. These samples were freeze-dried and kept frozen at -80 °C until analysis. Ethanol extracts were prepared from the freeze-dried parts and used for analysis. The total polyphenol

content was quantified by the Singleton and Rossi method using the Folin-Ciocalteu reagent and expressed in mg of Gallic Acid Equivalent (GAE)/100 g of dry weight (dw). The antioxidant activity in the ethanol extracts from V. triquetrus was analysed by the Ferric Ion Reducing Antioxidant Power (FRAP), according to Benzie and Strain method, and the ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)) radical scavenging activity, as described in the Re method. While FRAP was expressed as μmol Fe2+/g dw, ABTS used μmol Trolox Equivalent (Trolox Eq)/100 g dw as units.

RESULTS AND DISCUSSION

There were differences between the visceral mass and head-foot part of V. triquetrus. In fact, regarding polyphenol content, whereas the mantle part contained a total of 142 ± 14 mg GAE/100 g dw, the visceral mass reached a high level of 314 ± 90 mg GAE/100 g dw. The high standard deviation resulted from a substantial variability between individuals, which may also be affected by digestive contents at the moment of capture. On the other hand, the antioxidant activity as measured by FRAP showed a similar pattern of higher values in the visceral mass than in the mantle, 55.6 ± 18.3 μmol Fe2+/g dw vs 9.8 ± 0.8 μmol Fe2+/g dw. Finally, the ABTS methodology largely agreed with polyphenol levels and FRAP, being the mantle with 1189 ± 223 μmol Trolox Eq/100 g dw less antioxidant than the visceral mass, 5511 ± 2304 μmol Trolox Eq/100 g dw.

CONCLUSION(S)

It may be concluded that the gastropod V. triquetrus can be a source of polyphenolic compounds, being specially its visceral mass, not only a rich source of polyphenols, but also a starting material for highly antioxidant extracts. Given the known antioxidant (and, also, anti-inflammatory) activity of polyphenols and the convergence of results with the FRAP and ABTS antioxidant activity methods, further study on the specific phenolic composition and extract fractionation and refining is warranted.

Lipidomic profiling and anti-inflammatory activity study of a poorly known marine organism, a Vermetid mollusk in the Portuguese shore

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Abstract

INTRODUCTION

The Vermetidae is a very specific and poorly studied family within the gastropods. The vermetids are usually found in coral reefs and on rocky shores, but little is known about their basic biology, metabolism, biochemical composition, and biological activity. These wormsnails have an irregularly uncoiled calcareous shell, cemented to or embedded in the hard substrate, and are active and passive suspension feeders. They excrete a stycky mucus net, which is suited to capture near-bed small planktonic organisms. Two main parts of the animal can be distinguished: the head-foot and the visceral mass. In the Mediterranean shores, Vermetus triquetrus is an abundant species and forms reefs, but is a poorly explored marine resource.

AIM RESEARCH

Taking into account that there are no studies about the lipid fraction and biological activity of components from V. triquetrus, this gastropod in the Portuguese shore was harvested from the wild and subjected to a thorough lipidomic study coupled to an anti-inflamamtory potential exploration, being the visceral mass and the head-foot part studied in separate.

MATERIAL/METHODS/DESIGN

A representative sample of V. triquetrus from the southern Portuguese shore was harvested on 19th March 2025. A careful dissection of the collected specimens was performed to separate the visceral mass and the head-foot part of the animals. The lipid classes, including triacylglycerols (TAG), diacylglycerols (DAG), monoacylglycerols (MAG), free fatty acids (FFA), sterols (ST), glycolipids (GL), and phospholipids (PL), were identified and quantified by High-Performance Thin Layer Chromatography (HPTLC). The fatty acid profile of the lipid fraction was analysed by a Gas Chromatography system with Flame Ionization Detector, GC-FID. The anti-inflammatory activity in the lipophilic extracts from V. triquetrus was analysed through an enzymatic methodology based on the inhibition of the cyclooxygenase-2 (COX-2), an enzyme involved in pro-inflammatory pathways in the human body.

RESULTS AND DISCUSSION

For the visceral mass and the head-foot part of the animal, the lipid class distribution revealed a combination of TAG, PL, and other lipid classes, being not too dissimilar from other taxonomically related species. The distinctiveness of the observed specific traits of the V. triquetrus lipid fraction harbor the possibility of providing a specific lipidomic signature that differentiates this marine resource from other similar taxa and neighbouring sessile marine organisms and communities. The observed traits coupled with further sampling according to season and different location may pave the way for a seasonal and geographical differentiation. The same can be mentioned about the fatty acid profile, which had a relatively particular mix of saturated, monounsaturated, and polyunsaturayed fatty acids. In accordance to the presence of anti-inflammatory compounds, such as polyphenols (more abundant in the visceral mass), anti-inflammatory activity, as measured by COX-2 inhibition, was detected.

CONCLUSION(S)

The vermetid gastropod V. triquetrus is still poorly studied and its physiology, metabolism, and biotechnological potential require further study. The current study intend to contribute to the knowledge still lacking of these animals, having shown the specific traits of its lipid fraction that harbor the possibility of providing a specific lipidomic signature.

Identification of bioactive peptides with potential for use in functional foods and feeds from mesopelagic fish & underutilised marine species

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Abstract

Mesopelagic fish are species found in the twilight zone (depths of 200–1000 m). These fish are abundant in our seas and are not used currently as a source of food or feed ingredients. They include species like Maurolicus muelleri (Mueller's Pearlside) and Benthosema sp. Previous work performed by our research group with EU & Norwegian collaborators as part of the MEESO project, identified bioactive peptides generated from mesopelagic species with potential health benefits. These benefits included the ability to inhibit enzymes important in regulation of inflammation and type-2-diabetes as well as high blood pressure. Along with mesopelagic species, underutilised shellfish and starfish species offer potential for use as feed and food ingredients when converted into hydrolysates and permeates using enzyme hydrolysis technology.

Several hydrolysates were generated from the mesopelagic species M. muelleri and Benthosema sp., as well as from spiny Seastars, common Seastars, green crab and brown crab using proteolytic enzymes including Alcalase and Papain. Hydrolysates were stabilised using freeze-drying or oven-drying at temperatures less than 45°C and subsequently characterised for their bioactive peptide content using a combination of mass spectrometry, in vitro bioassays, in silico analysis of identified peptides and chemical synthesis and characterisation of bioactive peptides. A strategy combining use of the Teagasc Ashtown suite of in vitro bioassays combined with in silico analysis identified ten novel peptides with anti-hypertensive, anti-diabetic, and anti-inflammatory potential. In addition, the umami potential of identified peptides combined with characterisation of volatiles found in shellfish and starfish hydrolysates was determined and will help to guide formulation of these ingredients to enhance taste and sensory experiences for selected target consumers and markets. Where bioactivities exist for hydrolysates and peptides, the half-life and enzyme EC50 values of peptides were determined. Five novel anti-inflammatory peptides were chemically synthesised and characterised further in terms of

solubility, bioactivity, and delivery in carriers. Results demonstrate the potential of mesopelagic fish and underutilised shellfish and starfish resources and hydrolysis to generate novel, health beneficial ingredients for potential use in foods and functional feeds.

Protein hydrolysates derived from side streams generated by Polish fish processing plants

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Abstract

The aim of the research conducted at NMFRI is to explore the feasibility of obtaining protein hydrolysates from by-product streams generated during fish processing and to assess their physicochemical and biological properties relevant to potential applications.

The Polish fish processing industry is highly fragmented, comprising over 230 plants—most of which are small or medium-sized enterprises lacking in-house R&D capabilities. This lack of institutional capacity reduces the potential for the innovative utilization of by-products, which are most commonly sold for animal feed, despite their significant potential for valorization into high-value compounds with applications in medicine, pharmaceuticals, and cosmetics, thereby enhancing their economic value.

Among the most commonly extracted compounds from fish by-products are collagen, chitin, and peptide hydrolysates. Notably, bioactive peptides derived from fish proteins exhibit several functional properties, including:

- Antihypertensive activity, primarily through inhibition of angiotensin-converting enzyme I (ACE inhibitors)
- Antimicrobial effects
- Antioxidant activity

The properties and yield of these compounds are strongly influenced by the fish species, the type of raw material used (e.g., skin, backbone, scales), and the specific hydrolysis conditions applied.

This study focuses on four fish species—two flatfish and two whitefish—commonly processed in Polish facilities. For each species, skin, backbone, and minced muscle tissue are subjected to enzymatic hydrolysis using three enzymes: pepsin, bromelain, and papain. The raw materials are sourced directly from processing lines, and all hydrolysis procedures are conducted in NMFRI laboratories.

Initial results indicate that the efficiency of hydrolysis varies depending on the enzyme used, fish species, and tissue type. The resulting protein hydrolysates are evaluated for their physicochemical properties and are fractionated based on molecular weight. Each fraction is subjected to bioactivity testing. Preliminary findings will be presented at the conference. Upon completion of the project, it will be possible to conduct a comparative assessment of the biological activities of protein hydrolysates

derived from 12 distinct by-product types, as well as to evaluate the activity of specific molecular weight fractions obtained from these hydrolysates.

Overcoming extraction hurdles and assessing biological activity in a major invasive seaweed species in Europe, *Rugulopteryx okamurae*

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Abstract

INTRODUCTION

The brown seaweed Rugulopteryx okamurae is a major invasive species in Europe, representing a threat to local ecosystems. This seaweed belongs to the Class Phaeophyceae, Order Dictyotales, and the Family Dictyotaceae, originating from the Pacific Ocean. Its exponential expansion in the Western Mediterranean and Portuguese Southern Coast has been characterized by intense blooms, that is, phases of very intense growth with huge biomass generation. The biomass of R. okamurae may have invaluable components, including biologically active substances. It has been noted that the invasive success of this species on the shores of Southwest Europe may be due to the potential presence of chemical defences. Namely, it has been identified a set of relevant secondary metabolites in R. okamurae collected on the coast of the Strait of Gibraltar, such as diterpenoids. There is a challenge in assessing application routes for this biomass and extracting components for its valorization. In this context, it is important to test different extraction technologies (overnight agitation, mechanical homogenization, pH-shift, ionic liquid-, and ultrasound-assisted extractions) and parameters.

AIM RESEARCH

This study had as its main objective to assess the potential of extracting contents and specific biologically active compounds from the biomass of the invasive seaweed R. okamurae and, also, to compare different technological processes (including different green solvents) and the respective operational parameters in achieving extracts with optimal properties.

MATERIAL/METHODS/DESIGN

Samples of R. okamurae were attained from algal beds deposited in Algarve beaches in Southern

Portugal. These samples were freeze-dried and kept frozen at -80 ºC until analysis. Aqueous, ethanol, ethyl acetate, isoamyl acetate, and ionic fluid extracts were prepared from the freeze-dried parts and used for analysis. A set of five different extractive methods were applied to the seaweed biomass, based on physical processes and/or chemical treatments. In the case of the former, overnight agitation, mechanical homogenization with a high velocity rotating disperser rod, and ultrasound-assisted extraction were applied. As to chemical processes, pH-shift and ionic liquid multi-step extraction were tested. The total polyphenol content was quantified by the Singleton and Rossi method using the Folin-Ciocalteu reagent and expressed in mg of Gallic Acid Equivalent (GAE)/100 g of dry weight (dw). The antioxidant activity in the ethanol extracts from V. triquetrus was analysed by the Ferric Ion Reducing Antioxidant Power (FRAP), according to Benzie and Strain method, and the ABTS (2,2′-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)) radical scavenging activity, as described in the Re method. While FRAP was expressed as μmol Fe2+/g dw, ABTS used μmol Trolox Equivalent (Trolox Eq)/100 g dw as units. The anti-inflammatory activity in the extracts from R. okamurae was analysed through an enzymatic methodology based on the inhibition of the cyclooxygenase-2 (COX-2), an enzyme involved in pro-inflammatory pathways in the human body.

RESULTS AND DISCUSSION

The results showed important advantages and drawbacks of different extractive techniques and approaches depending on the component to be extracted from R. okamurae biomass and parameter to be assessed. There was a higher yield in the extracts homogenized with 70 % ethanol, especially with 1:20, w/v, biomass:solvent ratio, than in the case of aqueous extracts. Regarding extraction through overnight agitation, 70 % ethanol produced yield results (24.5-28.3 %) similar to those found in the homogenized extracts. However, in the former, the best biomas:solvent proportion was 1:10, w/v. Mineral matter yield presented specific patterns, thereby reaching 59.6 ± 1.1 % (70 % ethanol) and 82.3 ± 0.1 % (aqueous extract). The highest total polyphenol level was attained in the 70 % ethanol, 1:20, w/v, extract, 310.7 ± 22.1 mg GAE/100 g dw seaweed. This extract had a higher antioxidant activity as measured by both the FRAP and ABTS techniques. The extract attained with overnight agitation, 70 % ethanol, 1:10, w/v, had a substantial level of anti-inflammatory activity, thereby reaching 48 % COX-2 inhibition.

CONCLUSION(S)

This study showed the potential of R. okamurae for pharmacological purposes, especially in the antioxidant and anti-inflammatory area, enabling rank technologies and conditions for the utilization of this abundant biomass resource by the industry. Overall, classical overnight agitation and ultrasound-assisted extraction were advantageous in terms of yield and activity.

Sequential extraction of polysaccharides and proteins from the invasive macroalga *Sargassum muticum*

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Abstract

Aim of research

This study aims to explore the valorisation of the invasive brown macroalga Sargassum muticum through a sequential biorefinery for the recovery of polysaccharides and proteins by using conventional and ultrasound-assisted extraction methods.

Materials/Methods/Design

Fresh Sargassum muticum biomass harvested in Cork, Ireland, was dried, milled, and subjected to sequential extraction. Three processing strategies were applied and compared in terms of yield: conventional extraction (C), ultrasound-assisted extraction at moderate amplitude (50%, USA), and ultrasound-assisted extraction at high amplitude (100%, USB). Extractions were performed using 0.2 M HCl as the solvent, followed by centrifugation, membrane ultrafiltration (10 kDa), and ethanol precipitation to obtain distinct fractions. The recovered streams included supernatants, retentates, permeates, and ethanol-precipitated fractions, which were subsequently freeze-dried for further analysis. These fractions (Figure 1) were characterised through proximate composition analysis, while the molecular weight distribution of polysaccharides and proteins was determined by size exclusion chromatography (SEC-HPLC).

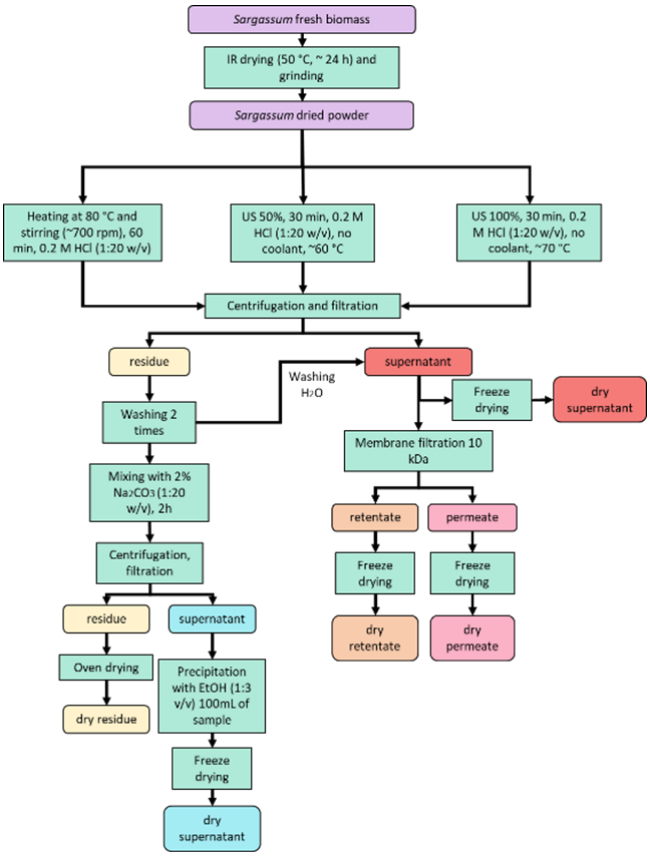

Figure 1. Process flowchart of sequential extractions of Sargassum muticum

Results and discussion

To evaluate the effect of conventional and ultrasound-assisted strategies on the sequential extraction of Sargassum muticum, the yields of the main fractions were quantified and are presented in Table 1. The table summarizes the recovery of soluble extracts, membrane-separated streams, ethanol-precipitated fractions, and the insoluble residue, with yields expressed as grams per 100 grams of dry biomass (mean ± SD, n = 3).

Table 1. Indicative yields (g per 100 g dry biomass; mean ± SD, n=3)

Fraction	Conventional (C)	USA (50%)	USB (100%)	Notes
Supernatant (acid extract)	4.2 ± 0.3	5.0 ± 0.4	6.5 ± 0.5	Soluble polysaccharides + soluble proteins/phenolics
Retentate (≥10 kDa)	1.2 ± 0.1	1.4 ± 0.1	1.7 ± 0.1	High-Mw polysaccharides + protein-rich
Permeate (<10 kDa)	2.0 ± 0.2	2.3 ± 0.2	2.6 ± 0.2	Oligosaccharides, peptides, and organic acids
Ethanol-precipitated fraction	2.6 ± 0.2	3.0 ± 0.2	3.4 ± 0.3	Enriched fucoidan/alginate; higher purity carbs
Residue (insoluble)	45.0 ± 1.5	42.0 ± 1.3	39.0 ± 1.2	Fibre + insoluble polysaccharides/protein complexes
Total recovered (excl. residue)	10.0 ± 0.6	11.7 ± 0.7	14.2 ± 0.8	USA ≈ +17%, USB ≈ +42% vs C

Conventional extraction (C) yielded a moderate recovery of soluble fractions, with the supernatant (4.2 ± 0.3 g/100 g) and the ethanol-precipitated fraction (2.6 ± 0.2 g/100 g) representing the primary streams. In contrast, the residue (45.0 ± 1.5 g/100 g) remained the dominant component, mainly composed of insoluble fibres and polysaccharides. Membrane separation effectively divided the extract into high-molecular-weight retentates (≥10 kDa; 1.2 ± 0.1 g/100 g) and low-molecular-weight permeates (<10 kDa; 2.0 ± 0.2 g/100 g), although both fractions contributed less to the overall yield. SEC-HPLC analysis revealed that the polysaccharides in the supernatant and ethanol-precipitate had a molecular weight distribution centered around 300 ± 30 kDa, consistent with intact fucoidans and alginates. In contrast, the protein peaks in the retentate were mainly in the 10–60 kDa range—application of ultrasound-enhanced recovery across all soluble fractions. At moderate amplitude (USA, 50%), yields increased by approximately 17% compared to C, with gains observed particularly in the supernatant (5.0 ± 0.4 g/100 g) and ethanol-precipitated fraction (3.0 ± 0.2 g/100 g). MW analysis indicated partial depolymerisation, with polysaccharide peaks shifting to 220 ± 25 kDa, while proteins remained broadly within the 10–60 kDa range. At high amplitude (USB, 100%), the effect was more pronounced, with total soluble recovery rising to 14.2 ± 0.8 g/100 g, representing a 42% increase over C. In this case, the insoluble residue decreased to 39.0 ± 1.2 g/100 g, confirming enhanced solubilisation. SEC-HPLC profiles revealed a more substantial depolymerization effect, with the polysaccharide Mw shifting further to 150 ± 20 kDa and an enrichment of low-molecular-weight oligosaccharides (<5 kDa) in the permeate.

The results demonstrate that ultrasound-assisted extraction not only improves the efficiency of biomass valorisation but also alters the structural profile of recovered biomolecules. USB maximised recovery but

produced lower-Mw fractions, while USA offered a balance between yield and preservation of macromolecular integrity. These findings highlight the potential of ultrasound to intensify sustainable biorefinery processes for invasive macroalgae, generating tailored polysaccharide and protein fractions for applications in food, cosmetics, and agriculture.

Conclusions

The findings confirm that a multi-ingredient biorefinery approach can provide a sustainable route for the valorisation of S. muticum, supporting circular bioeconomy objectives while mitigating the ecological impacts of this invasive species. Ultrasound-assisted extraction shows promise for enabling milder and efficient extraction, offering opportunities for industrial applications.

Acknowledgments

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African catfish in Central and Eastern Europe: consumer awareness, purchase experience, and market potential

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Abstract

Introduction
African catfish (*Clarias gariepinus*) is a warmwater freshwater species increasingly farmed in recirculating aquaculture systems (RAS) across Europe due to its high production efficiency, rapid growth, and environmental resilience. Production cycle from fry to market size (1,200–1,300 g) in RAS typically lasts 6–9 months, with low FCR values (0.95–1.0) indicating highly efficient feed utilization. According to 2021 estimates, total annual sales of African catfish in the EU reached approximately 12,000 tonnes [1]. RAS-farmed catfish is a medium-fat fish, with fillet analyses indicating a high content of polyunsaturated fatty acids (PUFAs), including EPA (0.06 g/100 g) and DHA (0.167 g/100 g) [2]. The species also shows moderate skinless filleting yield in standard processing procedures, reaching up to 39% for males and 34% for females [3]. These boneless portions are ideal for both retail packaging and foodservice applications, including ready-to-cook meals and culinary products.
Despite these advantages, African catfish remains little-known among consumers in Central and Eastern Europe. The aim of the studies was to investigate current levels of awareness and identify the key drivers and barriers to market acceptance.
Quantitative market research
A representative CAWI survey (n = 4,069 in total, with average n = 1,017 per country) was conducted in Poland, Lithuania, Romania, and Serbia in 2023. Respondents were asked whether they had encountered and purchased African catfish and what factors could convince them to try it. Across all investigated markets, a majority of respondents stated they had never seen African catfish for sale in stores or restaurants: 58% in Poland, 54% both in Serbia and Romania, with a slightly better situation in Lithuania, where 47% reported never having seen the fish on offer). Declared purchase levels of African catfish were marginal across all four markets. These results indicate that the species remains outside the mainstream consumer repertoire.
Respondents pointed to several motivating factors that could influence their willingness to try the

product. The most frequently cited reason was an attractive price, selected from 34% of respondents in Romania and Serbia, 39% in Lithuania, and up to 44% in Poland. Availability in the stores where they usually shop was another key condition for purchase, mentioned by 20% of respondents in Romania, 22% in Lithuania, 25% in Poland and up to 28% in Serbia. Consumers also indicated that convenient product forms, such as fillets or ready-to-cook formats, would be helpful, with this factor selected by 14% of respondents in Romania, 15% in Lithuania, 19% in Poland and up to 20% respondents in Serbia. Other important motivators identified in the study included the need for clearer information on how to prepare the fish and its culinary qualities, perceived health benefits and nutritional quality, as well as greater transparency regarding farming methods, all of which could encourage consumers to try African catfish.

Market Opportunities

Although current consumer awareness is low, the findings reveal a clear interest in African catfish, especially if it is presented in accessible formats with supporting information. The product aligns with modern trends in health-conscious eating and environmental responsibility. Marketing efforts should target middle-aged consumers in urban areas and highlight the fish's nutritional quality, clean farming, and culinary versatility.

African catfish is also highly adaptable to diverse product formats, from chilled and smoked fillets, to frozen burgers, minced products, or heat-preserved dishes in jars or cans (e.g., catfish in barbecue sauce or vinegar marinade). It is well-suited for a wide array of culinary preparations including salads, soups, dumplings, meatballs, pâtés, and sushi, with heat treatments having minimal impact on its nutritional value [3]. The versatility of the species — both in terms of product development and side-stream valorisation — represents a major asset in a circular, sustainable aquaculture value chain.

Conclusions

Low purchase levels of African catfish appear to result more from limited exposure and insufficient communication than from consumer rejection. Unlocking its market potential will require improving visibility, providing trustworthy information, and increasing availability in mainstream retail. With targeted efforts to raise awareness and address perceptual barriers, African catfish could emerge as a valuable, sustainable addition to the freshwater fish segment and support aquaculture diversification in Central and Eastern Europe.

References

[1] Krupska, J., & Kulikowski, T. (2023). Sum afrykański w światowej i krajowej akwakulturze (African catfish in global and national aquaculture). In T. Kulikowski (Ed.), Sum afrykański (stawada) – cenny produkt (African catfish – a valuable product) (pp. 11–38). Gdynia: Morski Instytut Rybacki – PIB. ISBN 978-83-61650-34-8.

[2] Szlinder-Richert, J. (2023). Walory żywieniowe mięsa suma afrykańskiego (Nutritional qualities of African catfish meat). In T. Kulikowski (Ed.), Sum afrykański (stawada) – cenny produkt (African catfish – a valuable product) (pp. 39–58). Gdynia: Morski Instytut Rybacki – PIB. ISBN 978-83-61650-34-8.

[3] Szulecka, O. (2023). Sum afrykański – charakterystyka technologiczna i możliwości wykorzystania w przetwórstwie rybnym i gastronomii (African catfish – technological characteristics and uses in fish processing and gastronomy). In T. Kulikowski (Ed.), Sum afrykański (stawada) – cenny produkt (African catfish – a valuable product) (pp. 59–90). Gdynia: Morski Instytut Rybacki – PIB. ISBN 978-83-61650-34-8.

Barriers and opportunities for the successful market introduction of novel algae-based products

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Abstract

Aim of research:
Cultivating seaweed presents numerous advantages, such as minimal reliance on freshwater or arable land. It does not require fertilizers, as it absorbs nutrients directly from the ocean. Additionally, seaweed cultivation enhances ecosystem services, including increased biodiversity. Seaweed is rich in bioactive compounds with potential applications in food, feed, cosmetics, and other products. Seaweed cultivation is the fastest-growing sector in aquaculture.
However, there are several challenges associated with seaweed cultivation. In Europe, seaweed farming remains small scaled compared to other regions, even though a substantial effort has been put into growing this industry. A major challenge is competitiveness; the industry must develop cost-effective product applications to remain viable. Businesses must continuously adapt to the evolving needs and preferences of consumers and companies to succeed. However, new product development is risky, and many new products do not succeed (Victory, et al., 2021).
Presently, under the EU projects AlgaeProBANOS and SeaMark, preliminary Go-To-Market (GTM) strategies have been formulated for 14 distinct algae products, encompassing 21 diverse applications. Implementing robust Go-to-market (GTM) strategies can be effective in minimizing the risk of new product failure (Kuester et al., 2018). Several of the products have in the last year been tested with customers. This study investigates the potential strengths and benefits, as well as challenges, associated with introducing new algae-based products to the market within a go-to-market (GTM) strategy framework.
Material/methods/design:
The information collected for the algae products is based on a survey distributed to key personnel among the industry partners involved in the development of algae products. The survey questions addressed the updated GTM strategy, customer feedback on the products, and analyzed the impact of this feedback on the GTM strategies. The updated GTM strategies were also compared to the preliminary GTM strategies.
Results and discussion:
An updated GTM strategy has so far been developed for 6 products. The products are:

- Dietary fibre for petfood
- Fucoidan as a cosmetic ingredient
- Fucoidan as a nutraceutical
- Green alginates as a cosmetic ingredient
- Green alginates as a food ingredient
- Green alginates in packaging

The updated GTM strategies are more detailed and product-specific compared to the preliminary GTM strategies. This increased specificity might be a result of that the industry partners felt more comfortable sharing their go-to-market (GTM) strategies following additional validation through customer testing. Comparing the go-to-market (GTM) strategies reveals that each product possesses unique strengths or benefits, all while maintaining a shared emphasis on sustainability and customer feedback to guide their approaches. Key sustainability strengths include the use of cultivated seaweed as a sustainable raw material and ingredient, as well as the implementation of sustainable processing methods characterized by zero waste, low water usage, and the reduction or elimination of chemicals. The degree of emphasis on these sustainability factors varies across the products. For cosmetic products certification such as COSMOS or NATRUE is highly important to ensure market uptake. These are criteria that companies must meet to ensure consumers that their products are genuine organic or natural cosmetics produced to the highest feasible sustainability practices.

Compared to the initial GTM strategies, providing science-backed efficacy supported in vitro and clinical testing has been important to ensure market uptake for both cosmetics, food and petfood products. In the EU, health claims for algae products, including both microalgae and macroalgae, fall under the Nutrition and Health Claims Regulation (NHCR). This regulation ensures that health claims made on food products, including those based on algae, are accurate and not misleading to consumers. The NHCR specifies the conditions under which health claims can be made, requiring scientific substantiation for claims related to the maintenance or improvement of bodily functions. Commission Regulation 655/2013, establishes the criteria for justifying claims in cosmetics marketing. These criteria include legal compliance, truthfulness, evidential support, honesty, fairness, and informed decision-making. Claims for cosmetic products, whether explicit or implicit, must be backed by "adequate and verifiable evidence," in other words scientifically verified (Lähteenmäki-Uutela, et al., 2021). So far only benefits of the fucoidan as a cosmetic ingredient have been validated. Experience shows that substantiating health claims through scientific validation is both time-consuming and costly.

Customer testing also identified potential market barriers in terms of the color of cosmetics and food products. Additionally, the smell posed a potential risk for green alginate as a cosmetic ingredient. Novel food approval was a potential challenge for fucoidan as a nutraceutical in the EU market. For the other products changes in regulations could become both an opportunity and challenge.

Conclusion:

The industry partners in SeaMark and AlgaeProBANOS have developed 14 preliminary and 6 updated GTM strategies. The updated GTM strategies are more detailed and product-specific, likely due to increased confidence from industry partners following customer testing.

Sustainability is recognized as a key strength in the updated go-to-market (GTM) strategies for the six

targeted algae-based products. Regulatory changes that increase the demand for sustainable products, by for example setting stricter standards for the total footprint of products, might enhance both the demand for and willingness to pay for algae products. However, these changes could also prompt buyers to switch to alternative products, due to the price of algae. Increasing the price of algae products is vital in order to achieve profitability, as the cost of producing algae in Europe is high.
Scientific validation of health claims will be important for the market uptake of the petfood, cosmetics and nutraceutical products, especially in the EU. This will require a substantial effort from the companies developing these products.
Some customers expressed a preference for a cosmetic product that was white and odorless, which needs to be addressed to meet their needs and facilitate sales.
Novel food approval posed a potential challenge for fucoidan as a nutraceutical in the EU market. This approval was identified as a challenge for most food products in the preliminary GTM strategies, and it will be crucial to obtain it for other food products to be sold in the EU market.
References:
Kuester, S., Konya-Baumbach, E., & Schuhmacher, M. C. (2018). Get the show on the road: Go-to-market strategies for e-innovations of start-ups. Journal of Business Research, 83, 65-81.
Lähteenmäki-Uutela, A., Rahikainen, M., Camarena-Gómez, M. T., Piiparinen, J., Spilling, K., & Yang, B. (2021). European Union legislation on macroalgae products. Aquaculture International, 29, 487-509.
Victory, K., Nenycz-Thiel, M., Dawes, J., Tanusondjaja, A., & Corsi, A. M. (2021). How common is new product failure and when does it vary? Marketing Letters, 32(1), 17-32.

Species monitored in Portuguese shellfish coastal production areas during the last decade

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Abstract

INTRODUCTION

The National Bivalve Mollusc Monitoring System (SNMB) in Portugal is, under the terms of Article 3 of Decree-Law 68/2012 of 20th March, an integral part of the mission and attributions of the Portuguese Institute for the Sea and Atmosphere, I.P. (IPMA, I.P.), which is, as provided for in Decree order No. 1421/2006 of 21st December and its amendments, the competent entity to: i) Classify the production areas (ZDP) of bivalve molluscs; ii) Monitor the production areas of bivalve molluscs and establish the sampling plans; and iii) determine, according to the monitoring results , the temporary closing and/or reclassification of the production areas.

AIM

The present work aims to present the main shellfish species of commercial interest monitored in the last decade in the coastal bivalve mollusc production areas in mainland Portugal, both from wild banks and aquaculture.

RESULTS

Considering the last decade, the number of monitored species in Mainland Portugal more than doubled in coastal areas. The results demonstrate that there has been a diversification and an increase in the number of species originating from aquaculture in the southern Portuguese shore. The availability of the species existing in each production zone, on the IPMA website, is important for stakeholders, competent authorities and the general public.

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K-EAT: Sharing scientific knowledge to build up responsible and aware consumers of tomorrow

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Abstract

One of the most ambitious challenges of today is how to ensure access to safe and sustainable animal protein to a growing world population without burdening natural resources (including water, arable soil) and biodiversity, while adapting to and mitigating the impact of climate change. Well established (aquaculture) and novel (insects both as food and feed) productions have been recently proposed as valuable solutions to face this challenge (FAO, 2021). Aquaculture can help reduce the need to catch wild fish and allows for food-safe products, given the ability to control the various stages of farming. With the increasing demand for sustainable protein sources in fed aquaculture worldwide, new protein ingredients were developed to replace conventional animal protein both in human and animal nutrition. Among these, insects offer a sustainable and eco-friendly alternative, also from the perspective of entomophagy. However, several studies have underlined that European consumers are still biased against farmed fish and entomophagy. On one side, they believe that aquaculture products are less fresh, of lower quality, and worse in nutrients and taste than wild fish (Claret et al., 2014), even if tests on the nutritional and sensory evaluation of different species (e.g. turbot, European sea bass and gilthead sea bream) showed that consumers prefer, from an organoleptic point of view, the farmed fishes (Claret et al., 2016). Hence, these prejudices rely more on the image of aquaculture products, perceived as artificial, and on the lack of information about this farming practice than on their actual and real characteristics. Social learning, defined as “a transitional and transformational process that can help create the systemic changes needed to meet the challenge of sustainability”, has been proposed as a powerful tool in the development of a sustainable world (Wals et al., 2007). In this regard, childhood is pivotal. The importance of integrating education for sustainability in early childhood education is well established (Davis, 2015). For instance, a study conducted in 2011 found positive effects of education for sustainability in promoting young children’s attitudes, well-being, health, and intellectual and social

behavioural development (Muennig et al., 2011). Recently, the Food and Agriculture Organisation published the book “Farmers of the water” that can be considered as a milestone for aquaculture education, since it represents an educational toolkit developed as part of a wider initiative, within the framework of the Scientific Advisory Committee on Aquaculture (CAQ), to stimulate learning and promote the social acceptability of the aquaculture sector (FAO, 2025).

Hence, the aim of K-EAT (Know and Eat) project (code P2022PWENM, financed by the Italian programme PRIN PNRR) was to raise awareness of fish farming and entomophagy, mixing storytelling, gaming, and experiencing as tools to share scientific knowledge and promote educational activities on sustainability, biodiversity, and healthy eating habits during childhood.
To reach these goals, we involved three elementary/primary schools, two located in Lucca and one in Florence (both in Central Italy), with a total of eleven classes (n. 243 students from 8 to 11 years old). Teaching activities were co-created with the teachers, specific for each age. Four lessons of two hours each were planned: two about fish and aquaculture and two about insects and entomophagy. Lessons were designed to include short theoretical parts in order to spend more time in practical activities and workshops where pupils were actively involved in the learning process, while also trying to stimulate exchange and debate.

In the first lesson, with younger pupils, we read a story where the protagonists set off on a journey to discover ways to feed everyone without damaging the planet; with other pupils, we talked about the importance of proteins, how they are made and in which food we can find them most. From here, we started talking about fish and saw how to read the label of fish products: the scientific name of the species, where the fishes we eat comes from, how they were caught or if they were farmed or wild. Then we played a game about overfishing and explained the negative effects of this phenomenon, introducing aquaculture as a possible solution to reduce pressure on wild fish stocks. As homework assignments, we asked to the pupils to do short research on which fishes are mainly farmed in the various continents and to investigate one species in particular. During the second lesson we discussed the homework and read a comic we designed about sustainable aquaculture that explained how aquaculture works, why it is important and also we provided some historical background. Then, we also explored the characteristics of aquaponics, as an example of sustainable farming system, in order to create a model of an aquaponics system using recycled materials (Figure 1).

Figure 1: Model of aquaponics made with recycled materials

The other two lessons were dedicated to insects and entomophagy. The educational path with the classes ended with a field trip to Molin di Bucchio (Arezzo, Central Tuscany), where there is an ancient aquaculture plant and species are farmed both for food consumption and for the river restocking with endangered species. The pupils had the opportunity to see and experience firsthand some of the topics covered in classroom.

The pupils participated actively in every activity and, from the interest shown, the many questions asked, it was clear how they had internalised the themes approached. At the beginning of the activities, considering that there were 20 children per class on average, almost all showed indecision about eating farmed fish and insects. At the end of the activities, about half stated that they felt ready to taste these products. The pupils explained that their change in opinion was due to an increased awareness regarding the topics considered, confirming that familiarising consumers with these themes is essential to build a positive perception, so that sustainable aquaculture and entomophagy can be further developed.

References

Claret A, Guerrero L, Ginés R, Grau A, Hernández MD, Aguirre E, Peleteiro JB, Fernández-Pato C, & Rodríguez-Rodríguez C.(2014). Consumer beliefs regarding farmed versus wild fish. Appetite, 79:25-31.

Claret A, Guerrero L, Gartzia I, Garcia-Quiroga M & Ginés R. (2016). Does information affect consumer liking of farmed and wild fish? Aquaculture, 454:157-162.

Davis JM (2015). What is early childhood education for sustainability and why does it matter? In JM Davis (Ed.), Young Children and the Environment: Early Education for Sustainability [Second Edition] (pp. 7–31). Port Melbourne: Cambridge University Press.

FAO. 2021. Looking at edible insects from a food safety perspective. Challenges and opportunities for the sector. Rome. https://doi.org/10.4060/cb4094en

FAO (2025). Farmers of the water – Education toolkit for the Blue Transformation of aquaculture in the Mediterranean and the Black Sea. Rome. https://doi.org/10.4060/cc8729en

Muennig P, Robertson D, Johnson G, Campbell F, Pungello EP & Neidell M (2011). The effect of an early education program on adult health: The Carolina Abecedarian project randomized controlled trial. Am J Public Health, 101:512–516.

Wals AEJ & van der Leij T (2007). Introduction. In AEJ Wals (Ed.), Social learning towards a sustainable world: principles, perspectives, and praxis (pp. 17–32). Wageningen: Wageningen Academic Publishers study. J Aquat Food Prod Technol, 29:445-460

Acknowledgments

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Sales potential of carp (*Cyprinus carpio*) in Poland through short food supply chains: consumer research insights

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Abstract

Background

Short food supply chains (SFSCs) are defined in EU policy as food distribution channels involving few intermediaries and fostering close local links between producers and consumers. The concept gained prominence under the EU Rural Development Programme 2014–2020, which encouraged producers to engage in SFSC initiatives (e.g. direct sales) with financial support. Such short chains are seen as a way to improve sustainability and reconnect consumers with food origins. While SFSCs are often discussed in the context of farm produce, they are equally relevant for fisheries and aquaculture. For fish – and carp in particular – SFSC models (like on-farm sales, farmers' markets, and local fishmongers) can provide more fresh products and greater transparency of origin, strengthening consumer trust. Carp is a culturally important fish in Poland (especially during Christmas season), and leveraging SFSC channels for carp could enhance its market appeal by highlighting freshness, local provenance, and direct producer-consumer relationships.

Methods

This study employed a mixed-methods approach to investigate Polish carp consumer behavior regarding those specific fish and SFSCs. First, a nationally representative quantitative survey (N=534) was conducted via CAWI (computer-assisted web interviews), capturing consumers' awareness, attitudes, and purchasing habits related to carp in short supply chains. This was complemented by qualitative research in the form of focus group interviews (4 FGIs, each 8 participants, in total n=32), which provided in-depth insights into the motivations and barriers behind carp purchasing choices and explored how consumers perceive information and marketing for carp in SFSCs. The combined findings offer a comprehensive view of both broad trends and nuanced consumer perspectives.

Results

Consumer familiarity with the SFSC concept is limited: only about 40% of Polish respondents recognized

the term “short supply chain” in the context of food/fish products. Despite this moderate awareness, actual engagement with short supply chain channels for carp is considerable. Up to 50% of carp consumers reported that they purchase carp via SFSC outlets – including direct from fish farms, at local marketplaces or bazaars, and other 29% - through traditional small fish shops, which could also be rocognised as SFSC outlets. These findings indicate a substantial existing base for short-chain carp sales.

Consumers articulated numerous advantages of buying carp through SFSCs. The most frequently cited motivation is superior freshness – 60% of survey respondents said they choose SFSC outlets because of the “better, guaranteed freshness” of carp bought directly. Traceability and trust in origin are also key drivers: 50% value knowing where the product comes from. Many respondents (41%) highlighted a form of local patriotism. Economic and environmental factors also play a role – 42% cited a lower price, and 39% appreciated environmental friendliness. These motivations underscore that consumers who use SFSCs perceive clear benefits.

However, several barriers exist. About 30% of consumers lack information on where to buy carp via SFSCs. A related concern is insufficient promotion – many are not aware of opening hours or locations. Convenience is also an issue: 30% find the distance a barrier, 23% dislike that they cannot combine such purchases with other groceries, and 16% find product forms inconvenient. Price perception is mixed: while many see direct sales as cheaper, 24% believe SFSC prices are higher.

Consumers rely heavily on informal networks: 29% rely on word-of-mouth from friends and family, 20% on local sellers, and only 20% cite the Internet. This suggests that in the absence of visible communication, consumers turn to trusted personal sources.

Conclusions

This research indicates strong potential to boost carp sales through SFSCs, provided certain challenges are addressed. Consumers already appreciate the benefits of SFSCs – freshness, traceability, local support, competitive pricing, and sustainability. Educational and marketing initiatives are critical: increasing awareness of where and how to buy carp directly, communicating SFSC benefits, and offering more processed product forms. Marketing efforts should reinforce positive associations with SFSCs. Empowering local sellers and leveraging word-of-mouth can help amplify these efforts. Aligning strategy with consumer insights offers a promising pathway to revitalizing direct carp sales in Poland, thereby boosting its consumption.

POSTERS

Functional edible films for fish preservation: Application of chitosan and gelatin based coatings with plant extracts

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Abstract

Edible coatings have emerged as effective strategies to extend the shelf life and maintain the quality of perishable foods, including fish. Chitosan and gelatin, both biodegradable and biocompatible biopolymers, have shown promising results in preserving freshness, delaying lipid oxidation, and inhibiting microbial growth in fish products. Their combination enhances the barrier properties and mechanical strength of coatings. Recent advancements include the incorporation of essential oils, particularly those from Mediterranean herbs, to further boost antioxidant and antimicrobial activity. Such enriched coatings represent a sustainable and functional approach to seafood preservation and food safety.

Aims:

This study aimed to evaluate the effects of single and composite biopolymer coatings (chitosan and gelatin), enriched with rosemary extract and sea fennel oil, on the quality and shelf life of refrigerated sardines.

Materials and methods:

All coatings were prepared at 1.5% (w/v) in distilled water (gelatin) or 1% (v/v) acetic acid (chitosan), gently heated and mixed for homogenization. Composite coatings were formulated by mixing chitosan and gelatin solutions (25:75, v/v). Enriched coatings contained either 20% (v/v) rosemary (Salvia rosmarinus) water extract or 0.5% (w/v) sea fennel (Crithmum maritimum) oil. Fish samples were dipped in the coatings for 2 minutes, allowed to drain, and stored at 0 °C. Controls included untreated and blank samples (dipped in 1% acetic acid).

Quality parameters were evaluated on days 0, 1, 4, 6, and 8 using sensory analysis (QIM), total volatile basic nitrogen (TVBN), lipid oxidation (TBARS), proteolytic index, and total viable counts (TVC). One-way ANOVA and Tukey's test ($p < 0.05$) were used for statistical analysis.

Results and discussion:
Shelf life, based on sensory analysis, showed minimal differences, in range from 8.3 to 8.7 days, with chitosan/rosemary-treated samples performing best. TBARS values differed among treatments, though no consistent trend was observed. TVBN values remained similar among treatments for the first 4 days, but on day 6, lower values were seen in chitosan, chitosan/sea fennel oil and chitosan/rosemary extract coatings. By day 8, the chitosan/sea fennel oil coating significantly reduced TVBN compared to all other treatments. Proteolytic index values were slightly better in chitosan/sea fennel oil coatings at the end of storage. TVC analysis showed that all treated samples had microbial counts 1–2 log units lower than control and blank groups, with the lowest counts in chitosan/sea fennel oil samples.
Conclusions:
Chitosan-based edible coatings, especially those enriched with sea fennel oil or rosemary extract, demonstrated a protective effect on sardine quality during refrigerated storage. These coatings effectively reduced microbial growth and proteolytic activity and partially delayed spoilage indicators such as TVBN and TBARS. Among all treatments, the chitosan/sea fennel oil coating showed the most consistent benefits, suggesting its potential for extending the shelf life of sardines in a sustainable and functional manner.
Funding:
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Cultivation of seaweeds with food process waters for sustainable protein production

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Abstract

Seaweeds have high productivity compared to many land-farmed crops, while also being rich in micronutrients B12 and having a favorable amino acid profile for human consumption. Seaweeds do not require any arable land, freshwater supply or high input of nutrients to grow. To make seaweeds competitive protein sources, their relatively low protein contents need to be increased. As part of the CirkAlg and SusWeed-projects, the aim of these studies was to investigate if herring production process waters (HPPW) can be used as cultivation media for seaweeds to increase their growth rate, protein content and thus create a high-quality protein source.

Briefly, the seaweeds U. fenestrata and P. palmata were cultivated in seawater with added HPPW, diluted to a normalized level of ammonia, as well as in controls with just seawater and with added artificial nutrients. This was followed by assessment of growth, crude protein content & amino acids post-harvest.

Crude protein levels of U. fenestrata cultivated in HPPWs reached >30%, similar to that of high-protein pulses such as soybeans. Also in P. palmata, the crude protein content increased. For both species, growth rate was also significantly raised when cultivated in HPPW. Growth increased by 1.5 times for P. palmata, and U. fenestrata yielded 4-6 times more fresh weight biomass by the end of cultivation. This demonstrates a great potential for cultivating seaweeds with HPPW to generate protein-rich biomass

while nutrients are being circulated back to the food chain. A novel nutrient loop is illustrated, in which the costly disposal of food HPPW is turned into value by seaweed cultivation.

University of Lincoln seafood engagement update

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Abstract

Through our Grimsby campus, the University of Lincoln has established working partnerships with several UK seafood businesses. We have been able to help with their staff development through our Future Seafood Leaders skills programme. We are also actively involved in collaboration projects in such areas a factory decarbonisation, supercooling of products & defrosting optimization.

Optimisation of enzymatic acidolysis of EPA+DHA from rainbow trout and tocopherols from maqui seed oil under supercritical CO_2 conditions

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Abstract

Long-chain n-3 polyunsaturated fatty acids (LC-PUFA n-3), such as eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids, are essential for human health. However, their supply is limited by the low conversion rate of α-linolenic acid and the variable content in marine sources, which is influenced by environmental changes and the diet provided to the marine species concerned. Notably, concentration by urea complexation and stabilisation with natural antioxidants offer promising alternatives for LC-PUFA n-3 disposal. This study aimed to synthesise a novel antioxidant bioactive lipid rich in EPA and DHA (ABL) using a concentrate of farmed rainbow trout (Oncorhynchus mykiss) belly oil (CB) and tocopherols extracted from cold-pressed maqui (Aristotelia chilensis) seed oil, through enzymatic acidolysis catalysed by Candida antarctica in supercritical CO_2. Characterisation of the oils and the ABL was carried out using gas-liquid chromatography (GLC), high-performance liquid chromatography (HPLC), thin-layer chromatography (TLC), differential scanning calorimetry (DSC), colour analysis, and assessment of traditional lipid hydrolysis and oxidation determinations. Maqui seed oil exhibited high contents of α-linolenic acid (10.63 g/100 g total fatty acids, TFAs), linoleic acid (53.55 g/100 g TFAs), and α-tocopherol (280.95 mg/kg). CB contained 49.57 g EPA+DHA/100 g TFAs. A 3^2 response surface design was applied to optimise the synthesis conditions. For it, supercritical pressure (100–300 bar) and temperature (50–80 °C) were considered as processing variables (i.e., independent variables); response variables included concentrations of DHA, EPA+DHA, α-tocopherol, β-tocopherol, and γ-tocotrienol. Optimal conditions (72.7 °C and 248.9 bar) yielded an antioxidant bioactive lipid containing 41.28 g EPA+DHA/100 g TFAs and remarkable levels of tocopherols and tocotrienols. These results highlight the value of agro-industrial by-products as sources of functional ingredients for food, nutraceutical, and cosmetic applications.

Comparative proximate, phospholipid and fatty acid values in edible and non-edible tissues of carp (*Cyprinus carpio*) cultivated in Madagascar

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Abstract

Chemical constituents of aquatic species have proved to be inhomogeneously distributed as a result of physiological and anatomical factors. Notably, the lipid content and composition have been recognised as the most highly affected, showing wide distribution differences among tissues in all kinds of species. In this study, the proximate composition, phospholipid content and fatty acid (FA) profile in edible (dorsal, ventral, and tail) and non-edible (liver) tissues of common carp (Cyprinus carpio) cultivated in Madagascar were determined. As a result, moisture showed to be the most abundant constituent both in edible (74-78%) and non-edible (60%) tissues. Protein values in edible tissues were included in the 15-20 % value, while the liver tissue showed a 12% content. The lipid content depicted the following decreasing sequence for the different tissues: liver > ventral > tail > dorsal; according to their structural role, total phospholipid presence showed the inverse sequence. Regarding the FA profile, monounsaturated FAs showed higher levels (48-53 g/100 g total FAs) than saturated FAs (STFAs; 28-30 g/100 g total FAs) and polyunsaturated FAs (PUFAs; 18-23 g/100 g total FAs) in all tissues taken into account. Additionally, the following increasing sequence for tissue values was detected for ω3/ω6 ratio and EPA and DHA contents: liver < ventral < tail < dorsal. Finally, edible tissues provided higher PUFAs/STFAs values (0.72-0.77) than the liver one (0.61). A remarkable different proximate and FA composition is concluded for the different tissues considered. Comparison to previous research focused on this cultivated species indicates the strong influence of the diet provided.

Biorefinery of bioactive compounds from cochayuyo (*Durvillaea incurvata*) through UAE and PLE

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Abstract

Lipid oxidation generates negative effects in foods, such as rancid and bitter flavours and colour changes. Furthermore, it has been linked to various diseases such as Alzheimer's, Parkinson's, cancer, cardiovascular disease, liver disease, and diabetes. The use of synthetic antioxidants, although safe at normal levels, could pose long-term risks, prompting the search for natural alternatives. The objective of this research was to extract phenolic compounds and hydrocolloids from D. incurvata, which have been shown to contain bioactive compounds such as antioxidants and tocopherols. To this end, a biorefinery was built using sequential extraction; first, ultrasound-assisted extraction (UAE) was used to extract hydrocolloids (alginate), and then pressurised liquid extraction (PLE) was applied to the residue to obtain phenolic compounds, thus utilising the raw material. Both methods were optimised by employing the response surface method (RSM) using Box-Behnken designs. Additionally, the yield of phenolic compounds using PLE alone and the UAE-PLE combination were compared. The optimal value for PLE was 10.89 (mg GAE/gdw) and 16.67 (mg GAE/gdw) for the combined extraction. This result demonstrates that the combined extraction utilizing the UAE residue yields a higher phenol content ($p < 0.05$). Furthermore, the alginate extract was characterised by employing the Fourier Transform Infrared Spectroscopy (FTIR).

Valorisation of tuna head by-products to obtain peptide fractions with in vitro antioxidant activity for aquafeeds

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Abstract

Introduction

Fish farming is highly dependent on the use of compound feeds, with national consumption in Spain reaching 181,000 tonnes in 2023. The formulation of aquafeeds is crucial to ensure the viability and sustainability of aquaculture systems. Fishmeal remains the predominant protein source in aquafeeds, with approximately 86% of its global production intended for aquafeed manufacture. The sharp increase in demand for fish meal for aquaculture and livestock farming, combined with declining fishery catches (e.g. anchovy, herring) has doubled the cost of this ingredient over the past two decades [1]. In this context, by-products from fish industry represent a cost-effective and sustainable feed source. In the case of tuna canning industry, which represents more than 70% of the total value of canned products produced in 2024, by-products can account for 60-70% of the weight of the processed fish. Heads are the main by-products resulting from tuna canning industry. Their composition makes them suitable for their conversion into aquafeed ingredients, presenting 15% w/w proteins and 13.5% w/w lipids as well as being source for minerals such as hydroxyapatite or calcium phosphates. However, their direct use in aquafeeds is challenging due to the presence of insoluble components and their deficient digestibility in larvae and juveniles. This can be overcome by the inclusion of variable levels of fish protein hydrolysates [2]. They not only improve the solubility, digestibility and palatability of the aquafeed, but also can display biological activities such as antimicrobial, anti-inflammatory or antioxidant, among others. The supplementation of aquafeeds with natural antioxidants, such as peptides, serves a double purpose: (i) extend the self-life of aquafeeds, where lipid and protein components are blended and (ii) neutralize the

reactive oxygen species (ROS) generated by the environmental conditions of aquaculture systems. The aim of this study was to recover antioxidant peptide fractions from tuna heads for potential use as functional ingredients in aquafeeds. To this end, tuna heads from canning industry were enzymatically hydrolyzed and then fractionated by sequential ultrafiltration using ceramic membranes with 1, 3, and 8 kDa molecular weight cut-offs. The resulting fractions were evaluated for their in vitro antioxidant activity (i.e. DPPH radical scavenging and ferrous ion chelation). This procedure allowed recovering peptide fractions with antioxidant activity to take part as functional ingredients of aquafeeds.

Materials and Methods

Skipjack tuna (Katsuwonus pelamis) heads were obtained from a local canning factory, presenting 38.4% w/w of protein, 9.6% w/w of lipid and 11.5% w/w of mineral matter. The homogenized suspension was fed to a enzymatic reactor, employing Alcalase® and Flavourzyme® (Novozymes, Denmark) as commercial proteases at pH 7.5, 55°C and enzyme-to-substrate ratio of 3% w/w. Alcalase® is extracted from B. licheniformis and contains subtilisin (EC.3.4.21.14) ¬—a broad-spectrum endoprotease — as main enzyme component. Flavourzyme® is an enzyme complex derived from A. oryzae exhibiting primarily peptidase activity.

The resulting hydrolysates were separated into different peptide fractions employing 3 ceramic ultrafiltration membranes (Tami, Nyons, France) of molecular weight cutoffs (MWCO) 8 kDa, 3 kDa, and 1 kDa. As shown in Figure 1, the membranes were arranged into two sequential configurations, and operated at volume concentration factor of 1.6, crossflow velocity 3.3 m·s-1 and 1 bar of transmembrane pressure. The resulting permeate and retentate fractions were analyzed for their protein content, molecular weight distribution by Size Exclusion Chromatography. Two in vitro activities: DPPH radical scavenging and ferrous chelating activity were determined on the peptide fractions.

Results

Tuna heads were grinded, homogenized and hydrolysed using commercial endo- and exoproteases. The sequential enzymatic treatment using Alcalase® and Flavourzyme® produced a protein hydrolysate (degree of hydrolysis 18.5%) which was subsequently separated by membrane fractionation, as shown in Figure 1. The MW distribution revealed that the final permeates F8F1 and F3F1 were rich in peptides ranging from 0.3–3 kDa and contained 16% w/w of free amino acids. This composition makes them suitable for their use protein ingredients in aquafeeds. for 5 h employing Alcalase 2.4L® and Flavourzyme ® (Novozymes, Denmark) as proteases.

As for the antioxidant bioactivities, DPPH radical scavenging was significantly improved in fractions F3F1 and R8, with IC_{50} values of 1.35 and 2.03 mg·mL^{-1}, respectively. Their different MW distribution suggests that DPPH radical inhibition could be modulated by either short-chain or large peptides, likely depending on their content in hydrophobic and aromatic residues. In contrast, metal chelating activity was mostly attributed to the presence of low MW peptides, as evidenced by the bioactivity displayed by the fractions F8R1 and F3R1 (IC_{50} ≈ 1.04–1.32 mg·mL^{-1}).

Figure 1. Layout of the enzyme hydrolysis and membrane fractionation sequence, showing the MW distribution and in vitro antioxidant activities of the peptide fractions.

Conclusion

The integrated process proposed in this work allows the valorisation of tuna canning by-products to obtain peptide fractions with specific MW distribution and antioxidant activities. These fractions could be incorporated in aquafeeds, not only improving their digestibility or palatability but also supplying natural antioxidants. Future research should focus on the inclusion of these ingredients in aquafeeds and their zootechnical validation.

References

1. Ahmed, N.; Thompson, S.; Glaser, M. Global Aquaculture Productivity, Environmental Sustainability, and Climate Change Adaptability. Environ Manage 2019, 63, 159–172.
2. Siddik, M.A.B.; Howieson, J.; Fotedar, R.; Partridge, G.J. Enzymatic Fish Protein Hydrolysates in Finfish Aquaculture: A Review. Rev Aquac 2021, 13, 406–430

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Farmed Atlantic cod in Norway: Status and challenges

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Abstract

Aim of research:
This study aimed to map the current status and key challenges in Atlantic cod (Gadus morhua) farming in Norway. The objective was to establish a fact-based foundation for future research and development to improve production conditions, fish welfare, and product quality across the value chain, from hatchery to consumer.

Material and methods:
The study combined qualitative interviews with five cod farmers and quantitative assessments of welfare and quality parameters in farmed cod. Biological and quality data were collected from fish obtained at a single commercial slaughterhouse. As the data were sourced from only one facility, the results may not fully reflect conditions across the broader industry. Welfare evaluations included histological analysis of skin, gut, and gonads, and radiographic examination of skeletal deformities. Quality assessments involved biochemical analysis of muscle and liver, sensory evaluation, and instrumental measurements of texture and color during storage.

Results and discussion:
The interviews identified gut health, feed composition, and regulatory inconsistencies as key challenges. Acute enteritis was reported as a major cause of mortality in the sea phase. Radiographic analysis revealed a high prevalence of vertebral deformities, with all sampled fish showing abnormal neck angles. Histological findings indicated mild inflammation in skin and gut tissues.
Quality assessments showed clear differences between farmed and wild cod, particularly in muscle texture, liver color, and spoilage patterns. Farmed cod lacked typical fishy odor during storage, likely due

to low levels of trimethylamine oxide (TMAO). Green discoloration of the liver, possibly linked to taurine deficiency, was observed in most fish.

Conclusion:
The study highlights several biological and quality-related challenges in cod aquaculture. Addressing these will likely require a multidisciplinary approach, including improvements in genetics, feed formulation, and production practices. Although based on a limited dataset, the findings provide a useful basis for further research and support the continued development of cod farming as a sustainable industry.

Antibiotic resistance and biofilm formation mechanisms correlated with the dominant microbiota along the whole fish production chain of aquaculture

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Abstract

Aim

This study aimed to investigate the correlation between dominant microbial taxa and the presence of antimicrobial resistance (AMR) and biofilm formation mechanisms across various stages of the aquaculture production chain, using shotgun metagenomic sequencing data. By linking specific microbial taxa with the distribution of resistance and biofilm-associated traits, the study provides valuable insights into potential microbial reservoirs and hotspots of resistance transmission within aquaculture environments.

Material/Methods/Design

Samples (surfaces, water, fishfeed, and fish) were collected from multiple spots along the whole fish production chain, including farming, harvesting, handling, processing, packaging/distribution, of a leading aquaculture industry in Greece and subjected to shotgun metagenomic sequencing. To evaluate potential correlations between the core microbiota and resistance or biofilm-related mechanisms at different sampling sites, hierarchical cluster analysis (HCA) was performed using Euclidean distance and Ward's linkage method. Prior to analysis, the data were transformed via Pareto scaling. The results were visualized via heatmap clustering plot.

Results and Discussion

The microbial community identified throughout the aquaculture production chain was predominantly

composed of the genus Psychrobacter, while in specific locations, genera such as Pseudomonas, Acinetobacter, Shewanella, Exiguobacterium, and members of the Roseobacteriaceae family were also detected. Clustering analysis revealed strong correlations between Psychrobacter and specific resistance and biofilm-associated mechanisms, such as ATP-binding cassette LapB, dDTP-glucose 4,6 dehydratase (related to biofilm formation) and multidrug antibiotic resistance protein, which is associated with enhancing efflux pump expression (antibiotic resistance mechanism). In contrast, Pseudomonas and Acinetobacter, which were found at specific locations (mainly surfaces from processing plant), were associated with other mechanisms related to antibiotic resistance, either directly (e.g., Streptomycin 6-kinase), or indirectly (e.g., 4-hydroxymandelate oxidase). On the other hand, Shewanella and Exiguobacterium, which were detected in distinct facilities (fishfeed and artemia, respectively) were also linked with other mechanisms related to biofilm potential (e.g., 4-hydroxy-5-phosphonooxypentane-quorum sensing mechanisms) or antibiotic resistance protein (lia operon protein LiaF). Finally, Roseobacteriaceae family that was detected in fishfeed (Artemia salina) did not exhibit any mechanism related to either antibiotic resistance or biofilm formation mechanisms. These associations suggest that certain microbial taxa may act as key hubs for the persistence and dissemination of resistance and biofilm-related genes, posing potential risks to seafood safety and public health, a fact that deserves further attention in the near future.

Conclusions

The present study demonstrates significant correlations between specific microbial taxa and the presence of antimicrobial resistance and biofilm-associated functions across different stages of the aquaculture production chain. The findings highlight the crucial role of microbial community composition in influencing resistance dynamics and biofilm formation potential. Importantly, the integration of metagenomic data with comprehensive statistical analyses has proven to be an effective approach to: i) elucidate complex microbial mechanisms relevant to seafood safety, ii) emphasize the importance of conducting such kind of studies on a global scale and iii) provide invaluable information to stakeholders for the development of targeted management strategies aimed at promoting sustainable aquaculture practices and ensuring the safety and quality of final products.

Acknowledgements

The research project is implemented in the framework of H.F.R.I Call “Basic research Financing (Horizontal support of all Sciences)” under the National Recovery and Resilience Plan “Greece 2.0” funded by the European Union –NextGenerationEU(H.F.R.I. Project Number: 16591).

Antibiotic resistance of Enterococcus spp. along the whole fish production chain of aquaculture in Greece

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Abstract

Aim

As aquaculture expands to meet growing global demands for protein-rich food, concerns over microbial contamination and antimicrobial resistance (AMR) have escalated. However, fish are extremely prone to microbial contamination, raising concerns about food safety and economic losses. The growing emergence of antibiotic-resistant bacteria (ARB), often fueled by the irrational use of antibiotics. These strains can spread resistance capacity through gene transfer to other bacteria, including pathogenic ones, making the problem more than difficult to control. This study focused on the investigation of microbial communities in aquaculture facilities and assessed their antibiotic resistance profiles against commonly used antibiotics. The findings provide useful insights in terms of revealing resistance patterns, emphasizing the need for more sustainable practices in fish production.

Material and Methods

Samples were collected from aquaculture facilities e.g. farming water, sinks, equipment (nets, etc.), working surfaces etc., and fish during harvesting, handling, processing, and packaging. Sampling was conducted at a leading aquaculture company in Greece. All samples were analyzed using microbiological analysis to isolate potential foodborne pathogens. Then, the isolated bacteria were identified using the MALDI Microflex LT. Each isolate was tested for resistance to a variety of commonly used antibiotics via the disc diffusion method. For antimicrobial susceptibility testing, an inoculum from each isolate was spread on the surface of a dried Mueller–Hinton agar plate to achieve an initial population of about 107 cfu. Antibiotic discs were placed twice on the medium surface and plates were incubated at the optimal temperature of each strain. After incubation, zones of inhibition were measured

in three different diameters (means ± stdev of inhibition zone (cm). Isolates exhibiting zones were classified as sensitive, while those lacking inhibition zones were considered resistant.

Results and Discussion

Potential pathogens such as Enterococcus faecium, Enterococcus faecalis, Serratia marcescens and Morganella morganii were mainly detected in all aquaculture facilities and fish samples. Of them, Enterococcus was found to be the most abundant bacterial group across most sampling points (both spots and fish) and thus, the strains of Enterococcus were chosen for antimicrobial susceptibility testing. Results revealed significant resistance of all Enterococcus strains to antibiotics commonly used in human therapy such as Vancomycin, Penicillin G, Erythromycin and Tetracycline. The majority of Enterococcus isolates exhibited a notable resistance to Tetracycline, and Erythromycin. Resistance to Vancomycin and Penicillin G was low, as indicated by large zones of inhibition, up to 3cm.

Conclusions

This study highlights the risk associated with the irrational use of antibiotics throughout the aquaculture production chain. The detection of antibiotic-resistant Enterococcus spp. in all facilities and fish of aquaculture raises concerns about food safety and public health. The recorded high resistance to Tetracycline and Erythromycin indicates selective pressure from antimicrobial misuse, while lower resistance to Vancomycin and Penicillin suggests some antibiotics remain effective. These findings emphasize the need for better hygiene, rational antibiotic use, and sustainable practices to reduce antimicrobial resistance in aquaculture systems, so that they can ensure the sustainability of aquaculture and the safety of fish products.

Acknowledgements

The research project is implemented in the framework of H.F.R.I Call “Basic research Financing (Horizontal support of all Sciences)” under the National Recovery and Resilience Plan “Greece 2.0” funded by the European Union – NextGenerationEU (H.F.R.I. Project Number: 16591).

Presence and distribution of Antibiotic-Resistant Bacteria in various pre-fattening and processing plant spots of aquaculture production system and fish via advanced statistical analysis

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Abstract

Aim

Aquaculture is a major producer of seafood globally supplying more than 50% of the fish, crustaceans, and mollusks consumed worldwide. As a main food/protein source it has tremendous potential to contribute significantly to food security and nutrition for the growing human population. However, aquaculture is an important reservoir of Antibiotic-Resistant Bacteria (ARB), hot spot of horizontal transfer of antibiotic resistance genes and environmental gateway of them to the natural environment. The irrational use of antibiotics in aquaculture has contributed to the emergence of ARB spreading in various spots along the stages of fish production chain (e.g. pre-fattening and processing plant). Therefore, bacteria with resistance to antibiotics, especially those commonly used in human therapy (same with those used in animal therapy), can be transferred from the aquaculture environment to farmed and/or wild fish and further to the consumers table through the food value chain, threatening public health. The aim of this study was to investigate the presence and the distribution of ARB in various spots along the stages of fish production chain, particularly of pre-fattening and processing plants in aquaculture, via advanced statistical analysis, in order to reveal the most contaminated spots with ARB.

Material and Methods

Bacterial strains isolated from various spots along the stages of fish production chain in aquaculture were tested for their susceptibility to 7 antibiotics (Streptomycin, Sulphonamides, Erythromycin,

Clindamycin, Vancomycin, Penicillin G and Tetracycline) and assayed via Disk Diffusion method (using dried Mueller–Hinton agar plates and an initial bacterial population of about 107 cfu). Each antibiotic was placed twice onto the medium surface for each isolate and incubated at 37°C for 24 h. Each inhibition zone was measured twice (two plates) in three different diameters (means ± stdev of inhibition zone (mm). The data obtained were subjected to Principal Component Analysis (PCA) via Varimax rotation. Factors with eigen value <1 were retained and the total distribution among both antibiotics and different spots were displayed in plots of the 2 first factors.

Results and Discussion

According to PCA, 4 main groups were generated. The first one included isolates mainly from processing plant exhibiting high correlation to Vancomycin, Erythromycin, Penicillin G, while the second one (isolated from both processing plant and fish), presented a slight correlation with Tetracycline. The third group included isolates from fish, water and surfaces from both farming and processing plants, which were closely related to Streptomycin and Sulphonamides. Finally, the last group included isolates from solely surfaces from processing plants, which exhibited positive correlation with Tetracycline and negative correlation with Clindamycin. These findings highlight the importance of such studies in better understanding the distribution of ARB throughout the aquaculture production chain, as well as define the most burdened with ARB spots, thus providing specific mitigation strategies to stakeholders to tackle such issues.

Conclusions

The findings of this study clearly demonstrate the widespread presence and distribution of ARB in various spots along the stages of fish production chain, particularly of pre-fattening and processing plants in aquaculture. PCA revealed distinct groupings of ARB, indicating site-specific resistance patterns, with the processing plant emerging as a significant hotspot of ARB. These results emphasize the critical need for targeted monitoring and control strategies, especially at the most burdened spots, as revealed from statistical analysis. Implementing good hygiene practices (GHPs), rational use of antibiotics and continuous surveillance can play a key role in mitigating the spread of antibiotic resistance in aquaculture systems and thus, protecting both public health and environmental sustainability.

Acknowledgements

The research project is implemented in the framework of H.F.R.I Call “Basic research Financing (Horizontal support of all Sciences)” under the National Recovery and Resilience Plan “Greece 2.0” funded by the European Union –NextGenerationEU(H.F.R.I. Project Number: 16591).

Sensitive ELISA and lateral flow immunoassay to detect fish traces in processed food

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Abstract

AIM OF RESEARCH

Fish is one of the most allergenic food that can be found as hidden allergen in processed products due to cross-contamination. In these cases, voluntary precautionary allergen labelling (PAL) can be used to communicate that risk. To avoid the indiscriminate use of PAL, an allergen management plan must be implemented in food industry, which requires sensitive and specific analytical techniques to control the unintended presence of fish in food. The aim of this study was the development and validation of a sandwich ELISA and a lateral flow immunoassay (LFIA) for the determination of fish traces in processed food.

MATERIALS & METHODS

Fish parvalbumin (PV) was selected as target protein due to its thermostability, abundance and for being the most allergenic protein in fish. PV was purified from cod, hake and trout extracts by heat treatment followed by precipitation with ammonium sulfate. PV was inoculated in rabbits to obtain antisera and the specific antibodies were purified by immunoaffinity chromatography. The obtained antibodies were conjugated with horseradish peroxidase to develop the ELISA, and linked to carboxyl-modified latex microparticles to develop the LFIA. These tests were validated following international

AOAC guidelines.

RESULTS AND DISCUSSION

Results showed that the developed ELISA is capable of detecting 0.4 ng/ml of PV and 1.0 μg/g of fish protein. In addition, it can detect 1.25 μg/g of fish protein in model food (Frankfurt sausages, croquettes and chicken broth) incurred with ground cod muscle and processed as in the food industry. The developed LFIA is capable of detecting 3.1 ng/ml of PV and 5 μg/g of fish protein. Additionally, it can detect fish protein in model food at levels of 10 μg/g (Frankfurt sausages) and 5 μg/g (croquettes and chicken broth). Both tests were assayed on a panel of more than 50 basic ingredients without any cross-reactivity. When analyzing complex food matrices spiked with a cod extract, the tests showed high recoveries (63.6-114.3 %). Besides, both tests showed to be robust.

CONCLUSIONS

The developed ELISA and LFIA tests could be applied in allergen management in the food industry, avoiding the abuse of PAL. Furthermore, according to the detection levels recommended by the FAO/WHO, both tests are sensitive enough to protect 95 % of fish allergic consumers.

Effect of essential oils compounds against histamine-producing bacteria

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Abstract

Histamine fish poisoning is a foodborne intoxication primarily caused by the consumption of fish products with a high histamine content. In this type of product, histamine is formed by the decarboxylation of histidine, produced by the exogenous decarboxylases generated by several bacteria. Examples of histamine-producing bacteria (HPB) include Morganella morganii, Raoultella planticola, Raoultella ornithinolytica, Hafnia alvei, Klebsiella pneumoniae, and Klebsiella aerogenes. The objective of the present work was to evaluate the antimicrobial effect of essential oil compounds against M. morganii and K. aerogenes and determine their potential to prevent histamine accumulation in fresh fish. To achieve this goal, the bactericidal effect of carvacrol, thymol, eugenol, vanillin, and geraniol was determined. The obtained results indicated that all the tested compounds were able to inhibit bacterial growth, with the most effective components being carvacrol, thymol and eugenol. Then, both bacteria were exposed to bactericidal and non-bactericidal concentrations to determine bacterial survival and evaluate the impact of these components on the capability of these bacteria to generate histamine. These compounds were effective in reducing bacterial growth and also in controlling histamine production, even at non-bactericidal exposure. This effectiveness demonstrates that the use of natural preservatives obtained from essential oils would be an interesting strategy to prevent histamine formation in food products, contributing to food safety.

Development of photonic multi-sensing system for histamine analysis in fish products

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Abstract

The development of simple analytical devices for the assessment of the quality and freshness of fish in a rapid and inexpensive way is an issue of increasing importance. In the field of food safety, histamine detection is extremely urgent since consumption of fish with high levels of histamine can lead to scombroid fish poisoning (or histamine fish poisoning). In the present study, we have evaluated the feasibility of a novel photonic multi-sensing system to quantify histamine content in fish products. For this purpose, an extraction protocol using a buffer solution was optimised according to the photonic system requirements. The extraction yield of the new method was compared to the acidic extraction established in the ISO reference method (ISO 19343:2017) by determining the recovery values obtained by both protocols. The buffer extraction yield was similar to the acidic extraction, which indicates that this new protocol can be an alternative to the reference extraction, and also fulfils sensor requirements. Fish extracts obtained by the buffer extraction were analysed by the HPLC method and the results were compared with those given by the developed plasmonic sensors. The results indicated a high correlation between both methodologies. The proposed sensor fulfils some important requirements of Green Analytical Chemistry such as simplicity, the use of non-contaminant reagents and no sample derivatization.

Bioactivity of *Calanus finmarchicus* during in vitro gastrointestinal digestion

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Abstract

Aim of research

The marine environment, which covers approximately 71% of the Earth's surface, contains vastly untapped resources that can be utilized as food and feed ingredients, nutraceuticals, pharmaceuticals, and cosmetics. Low-trophic marine species have potential to supply essential nutrients and bioactive compounds sustainably and securely. In particular, one calanoid copepod species, Calanus finmarchicus, is gaining increasing interest.

Natural bioactive compounds can be alternatives to synthetic drugs in supplementing micronutrients and reducing the development of noncommunicable diseases, such as cardiovascular diseases and diabetes. Marine-derived bioactive peptides typically consist of 3 to 20 amino acid residues and may exhibit antioxidant, anticancer, antimicrobial, and anti-inflammation activities. The potentially bioactive peptides are released from their original protein structures during gastrointestinal digestion, enzymatic hydrolysis, or fermentation. In vitro gastrointestinal digestion models are considered cheaper, more ethical, and more controllable than in vivo digestion models. A standardized in vitro gastrointestinal digestion model offers good reproducibility and repeatability.

This research aimed to explore the potential health benefits of C. finmarchicus and its products and to reflect on their potential utilization. More specifically, the antioxidant and antidiabetic activities of the water-soluble fractions collected during a standardized simulated digestion process were analyzed using in vitro bioactivity assays.

Material/methods/design

The materials used in this study are fresh C. finmarchicus, C. finmarchicus hydrolysate, and freeze-dried C. finmarchicus. Fresh C. finmarchicus biomass was harvested by trawling, instantly frozen on board, and provided by Zooca® (Tromsø, Norway). A C. finmarchicus hydrolysate, a by-product of the oil

extraction process using enzymatic hydrolysis, was purchased from Zooca. Lastly, one portion of the fresh C. finmarchicus biomass was freeze-dried to produce the freeze-dried C. finmarchicus sample. The porcine digestive enzymes pepsin and pancreatin, bile extract, and 1 M HCl and NaOH solutions were used to simulate the gastrointestinal digestion process. Digestion samples collected at 0 min, 30 min, 75 min, 105 min, and 165 min during in vitro digestion were assessed for their putative antioxidant and antidiabetic activities. The antioxidant activity was tested using the ferric reducing antioxidant power (FRAP) assay and the oxygen radical absorbance capacity (ORAC) assay. The antidiabetic activity was screened using the dipeptidyl peptidase IV (DPP-IV) inhibitor assay and the protein tyrosine phosphatase 1B (PTP-1B) inhibition assay.

Results and discussion

The results of the FRAP assay and the ORAC assay indicated that C. finmarchicus, freeze-dried C. finmarchicus, and C. finmarchicus hydrolysate released water-soluble compounds exhibiting antioxidant activity during simulated gastrointestinal digestion. On the contrary, the water-soluble compounds released during simulated digestion demonstrated limited antidiabetic activities as tested by the DPP-IV inhibitor assay and the PTP-1B inhibition assay. Overall, fresh C. finmarchicus can potentially be a good source of natural antioxidants with lower production costs compared to C. finmarchicus hydrolysate and freeze-dried C. finmarchicus. However, C. finmarchicus hydrolysate and freeze-dried C. finmarchicus contain less water and have characteristics favored by production industries. Future studies are encouraged to test the antioxidant activity of C. finmarchicus and its products using cell-based assays.

Fish meat hydrolysates as bioactive peptides source

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Abstract

During the recovery of fish meat from backbones or the processing of meat trimmings using enzymatic methods, a significant amount of protein is recovered as a pool of soluble peptides and amino acids. These hydrolysates are not only a rich source of nitrogen, but can also have biological effects, due to the anti-oxidant, anti-hypertensive, anti-immumflamatory, anti-cancer etc. properties of biopeptides. These properties depend on the raw materials and enzymes used for proteolysis. The antioxidant activity of products during further digestion will additionally change depending on the composition before and after hydrolysis.

The aim of the study was to compare the antioxidant activity of hydrolysates obtained from fish meat models (muscles and muscle proteins isolates) by two different enzymes preparations (Pancreatin and Protamex®). Moreover, hydrolysates were subjected to digestion simulation and changes were compared, depending on the primary hydrolysis.

The material for the study was a model of fish meat, obtained from trimmings after cutting out cod fillets. Protein isolates were obtained from the same raw material using the pH-shift method. Meat and isolate were subjected to enzymatic hydrolysis and then the hydrolysates were subjected to digestion simulation. In all hydrolysates the content of non-protein nitrogen, amino acids as tyrosine and peptides as well as antioxidant activity (ABTS, DPPH, FRAP) were determined.

It was found that the hydrolysate of the fish meat model obtained with the use of pancreatin was characterized by a higher content of amino acids and peptides than the hydrolysate of protein isolate. In turn, the use of protamex resulted in a higher concentration of amino acids ana similar of peptides in

isolate than in the tissue. Thus, the concentration of amino acids in the tissue hydrolysed with protamex was four times lower than in meat hydrolysed by pancreatin, but the concentration of peptides did not differ significantly, regardless of the type of enzyme. Antioxidant activity designated as TEAC and FRAP was higher in the case of meat model, while the ability to scavenge DPPH free radicals in the case of isolates, while it did not differ statistically significantly regardless of the enzyme used. During the digestion simulation, the amount of both amino acids and peptides increased significantly, with the largest increase occurring in the case of amino acids released during the digestion of isolates – it reached a level similar to that from the meat, despite the originally much lower concentration (an increase of approx. 8-fold vs. 2-fold). The increase of peptides in all cases was approx. 4-fold. This resulted in increased antioxidant activity in all digested samples, which did not differ significantly.
It can be concluded that fish muscle hydrolysates as well as fish proteins hydrolysates can be valuable sources of antioxidants. Applied enzymes influence on composition and antioxidant properties oof hydrolysates, however after digestion differences were less important. Therefore application of any hydrolysates (except of bitter) can increase antioxidant potential of ready products.

SESSION 5 - P17

Green extraction and separation processes for seaweed biorefineries

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Abstract

Seaweeds (SW) are among the most promising resources for the development of a sustainable economy. They have diverse applications in food production and the extraction of high-value compounds, and offer numerous socio-economic and environmental benefits. Despite their potential, the SW industry remains underdeveloped, as the fractionation of this biomass into multiple products faces several technical, environmental, and economic barriers. This project aims to develop green, efficient, and scalable extraction and separation processes and to integrate them into a biorefinery system to convert SW into multiple functional products. The study focuses on the development of promising extraction methods [1]: ultrasound-assisted extraction UAE, enzyme-assisted extraction EAE, and their combination in a unique step UAEE. Three seaweeds species, native to the French Opal Coast were selected for the study: Palmaria palmata and Porphyra umbilicalis (red seaweed), and Saccharina latissima (brown seaweed). The first step was the biochemical characterization of the three seaweeds which revealed several valuable compounds, including proteins, polysaccharides and sugars (floridoside and xylan in P.palmata, porphyran in P.umbilicalis, and alginate; fucoidan; mannitol and laminarin in S.latissima), polyphenols, and pigments (notably phycobiliproteins in red seaweeds and fucoxanthin in brown seaweed). To study the effects of the three extractions processes, a Design of Experiment (DOE) approach is being employed. The second part of the project concerned UAE extraction. The studied parameters were the ultrasound power (165 to 500W), the ratio S/L w/v (1/20 to 1/40) and the extraction time (10 to 20 min). Initial UAE tests showed for P.palmata improved process efficiency, with extracts containing up to 60% of dry matter. High power treatment (500W, 15 min, pulse 15/15) significantly increased yields, especially for phycobiliproteins (+49%) and total polyphenols (+25%) compared to conventional maceration (24h). Low ultrasonic power (165W for 5 to 15 minutes) is less effective for total polyphenol extraction (17 to 25% lower than 24h maceration). A more in-depth study

using Design of Experiments is currently underway to optimize the ultrasound conditions (ratio S/L, time, and amplitude), EAE and combined methods for the three seaweeds.

Consumer response to the introduction of a Mediterranean-style fish dish in Croatian university canteens

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Abstract

The Mediterranean diet is internationally recognized as a health-promoting and sustainable dietary pattern, yet its adherence in Mediterranean countries remains low, even within institutional food services such as university canteens. Meals in Croatian university canteens typically score low on the Mediterranean Diet Index, particularly due to low fish content and limited use of olive oil, herbs, and whole grains.

This study investigates student acceptance of a newly introduced fish-based meal aligned with Mediterranean diet principles. The dish was developed through a participatory process involving students (via focus groups and a national survey), nutritionists, chefs, and food technologists.

Using a structured on-site questionnaire, the research explored factors influencing students' decisions to purchase or not purchase the meal. Students who chose the new product were asked about their motivations, satisfaction, repurchase intentions, willingness to recommend the product, and perceived price adequacy. Those who did not choose the meal were asked about their awareness of the product, reasons for not purchasing, price perceptions, and future intentions.

The results highlight both motivators and barriers affecting students' willingness to try and pay for fish-based dishes. The findings offer recommendations for increasing the share of Mediterranean-style meals in university canteens and provide insights into how institutional food environments can better support sustainable eating habits among young adults.

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Visual storytelling for science: a co-created comic on aquaculture

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Abstract

Aquaculture (breeding of aquatic organisms, i.e. fish) is recognized as strategic for the development of sustainable agri-food chains. Despite being an ancient practice in Europe, its development according to a productive and modern approach started from the mid-1970s and has grown steadily so much that today the global production volumes are 30 times higher than in 1970, reaching in 2022 a record of 130.9 million tonnes (FAO, 2024). Despite the high market demand for fish and seafood products, European aquaculture is stagnating; among other politic and bureaucracy issues, European consumers still prefer to eat wild fishes, since they are more positively perceived than farmed species (López-Mas et al., 2023). As recently reviewed by Budhathoky et al. (2024), "consumers perceived wild fisheries products are natural, healthier, nutritious, safer, and tastier, with higher quality and firmer flesh, while aquaculture products are cheaper, lower quality, and more readily available than wild fisheries". However, this contrasts with the sensory perception and liking score while tasting farmed fishes in no-informed conditions. It means that when consumers taste a fish fillet without know it comes from a farmed fish, the liking score was higher than the one received by the wild counterpart fish (Claret et al., 2016). Nevertheless, when they are informed about the origin of the fish, the liking score goes up for the wild fish and remains unchanged for the farmed ones. Hence, there is a bias. In this regard, the importance of education on this topic is thus crucial: if consumers are educated about the nutritional value, quality, safety and welfare of farmed fishes, they are prone to buy farmed rather than wild fish (Wongprawmas et al., 2022). Therefore, considering the importance of aquaculture to achieve the objectives of the UN Agenda 2030 for responsible production and consumption (Goal n. 12) and for maintaining life below water (Goal n. 14), initiatives to improve consumer awareness on benefits provided by aquatic products are necessary in Europe.

The use of comics in science education has been positively evaluated as a tool to communicate science results (Faria et al., 2023). The recent experience shared by Faria et al. (2023) revealed how the use of comics significantly increased students' motivation and commitment to the learning topics (specifically regarding evolution and biodiversity). Within the frame of Italian K-EAT (Know and Eat) project funded by Italian Ministry of the University and Research (code P2022PWENM, financed by the Italian programme PRIN PNRR 2022), we aimed to co-create with a graphic recorder a comic to provide a snapshot about sustainable aquaculture and its potential role for the citizen and environment too. To do this, the workflow was organised in the following four steps:

1. meeting with the research group and the recorder. During this phase the recorder "interviewed" the researchers about the overall project, the message we would communicate directly to the reader, and the specific contents to integrate;
2. one-to-one call with one researcher, trying to sharpen the idea, and to find a way around potential narrative issue;
3. co-creating the storyboard. The visual recorder proposed a first storyboard that was modified and integrated by the researchers to reach a final version;
4. sharing the approximate visual draft and revision of the same until the final version was achieved.

From the outset, the overall concept of the comic was carefully planned. It was intended for children aged 8 to 10, designed to fit a single A4 page (front side), and printed in black and white so that children could colour it themselves. The comic aimed to introduce the origins of aquaculture and explain its main goals.

In partial agreement with López-Mas et al. (2023), it was chosen not to highlight the negative aspects of either wild or farmed fish, nor to compare the two. Instead, we focused on narrating the story of aquaculture—what it is, where it comes from, the different methods of fish farming, and its purposes. Additionally, it was decided to include open-ended questions at the end of the comic, encouraging children to reflect on the topic independently, with their peers, or alongside their parents.

The first draft of the storyboard underwent several revisions. It was challenging to craft a narrative that flowed naturally through the key themes we wanted to present, while avoiding the comic becoming overly didactic or resembling an infographic. This process highlighted the vital role of brainstorming and collaboration among team members. As previously noted, interdisciplinary cooperation is essential for developing a storyboard that truly conveys the core concept.
The final version of the comic resulting from this process is shown in Figure 1.

Figure 1. Our final comic about aquaculture.

In conclusion, the co-creation process of a comic focused on aquaculture proved to be complex and multifaceted, ultimately resulting in a product that elicited an initial positive response from children, when the comic was presented to them, in the classroom. They were particularly drawn to the interactive element of colouring the comic. However, the narrative itself appeared somewhat difficult for them to follow, as many of them were uncertain about how to read and interpret the story. This represents a valuable point of reflection and a potential area for future improvement.

Whether the comic succeeded in stimulating discussion within the home environment remains an open question and deserves further investigation. Moreover, the response to the comic from older age groups or from children already familiar with comic reading conventions may also be assessed in subsequent evaluations.

References

Budhathoki, M., Tunca, S., Martinez, R. L., Zhang, W., Li, S., Le Gallic, B., ... & Little, D. (2024). Societal perceptions of aquaculture: Combining scoping review and media analysis. Reviews in Aquaculture, 16(4), 1879-1900. http://doi.otg/10.1111/raq.12927

Claret, A., Guerrero, L., Gartzia, I., Garcia-Quiroga, M. & Ginés, R. (2016). Does information affect consumer liking of farmed and wildfish? Aquaculture, 454, 157-162.

FAO (2024). The State of World Fisheries and Aquaculture 2024 – Blue Transformation in action. Rome, Italy. https://doi.org/10.4060/cd0683en

Faria, C., Valente, B. & Torres, J. (2024). Potentialities of science comics for science communication: lessons from the classroom. Journal of Science Communication, 23(08), N02. https://doi.org/10.22323/2.23080802

López-Mas, L., Claret, A., Arvisenet, G. et al. (2023). European consumers' beliefs about the main pillars of the sustainability: a comparison between wild and farmed fish. Aquaculture International, 31, 2035–2055 https://doi.org/10.1007/s10499-023-01070-2

Wongprawmas, R., Sogari, G., Gai, F., Parisi, G., Menozzi, D. & Mora, C. (2022). How information influences consumers' perception and purchasing intention for farmed and wild fish. Aquaculture, 547, 737504.

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The shark meat market: data trends and critical issues in the Italian context

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Abstract

The trade of elasmobranch meat has grown significantly over the years, as highlighted in WWF report (2021). Commercial exchanges between importing and exporting countries are numerous, and their scale represents a critical issue for the traceability of many species, many of which are classified as vulnerable or even critically endangered. In Europe, countries such as Spain and Portugal are leading exporters, with over 280,000 tonnes of elasmobranchs exported between 2009 and 2019. Italy, by contrast, is a net importer, having imported more than 88,000 tonnes of shark meat during the same period. Given the ecological and ecosystemic role of the elasmobranchs, often occupying top positions in the food chain, and their fragile conservation status further worsened by climate change, habitat degradation, and their inherently slow reproductive cycles, providing updated data on shark meat market appears to be a crucial first step in understanding demand trends and identifying possible points of intervention to discourage its consumption.

The present contribution offers an in-depth analysis of the shark meat market in Italy, contextualized within broader European trends, based on data retrieved from public databases (ISMEA, EUMOFA/Eurostat, FAO, CIRPSE). To complement quantitative data, the study includes the results of a stakeholder survey aimed at understanding knowledge, practices, and perceptions related to shark meat marketing in Italy. Thirteen stakeholders from the seafood sector (retail, Ho.Re.Ca., wholesale) responded to an anonymous survey composed of 11 multiple-choice questions.

The study outlines a marked decline in domestic landings of elasmobranchs, dropping from an average of over 850 tonnes per year (2017–2019) to around 460 tonnes per year in the period 2020–2022. Despite

this reduction in national catch, shark meat imports remain consistently high, with over 5,000 tonnes imported in 2024, valued at approximately €25 million. The bulk of imports (1657,610 tons) consisted of refrigerated whole elasmobranchs (unspecified species) mainly from Croatia, France and Spain, or frozen (840,718 tons) primarily from Spain, Portugal, and Namibia. Species such as blue sharks (Prionace glauca) dominated the volumes as a unique species with 1383,566 tons, while processed products (e.g., fillets) remain marginal.

The commercial trade was characterized by a significant imbalance: imports exceeded exports by a factor of over 70 (5600 tonnes vs. 79 tonnes), indicating a strong internal demand. However, traceability is still limited, as most imported shark meat falls under broad customs European codes (e.g., HS 0302, 0303, 0304), making it difficult to identify the specific species. The inconsistency in nomenclature and categorization poses challenges for both market transparency and regulatory control.

To complement quantitative data, the study included the results of a stakeholder survey, which revealed that 84.6% of participants commercialized shark species such as common smooth-hound (Mustelus mustelus), blue shark (Prionace glauca), porbeagle (Lamna nasus), spiny dogfish (Squalus acanthias); also wings of rays were sold. Although the majority of the interviewees declared to have at least one species of shark in their catalogue, confirming a regular diffusion, sharks represent less than 5% of the value and volume of their annual commercial offer, representing less than 10 tons per year for over 90% of the interviewees.

In addition, confusion regarding species classification emerged. For instance, swordfish (Xiphias gladius), taxonomically unrelated to sharks, was wrongly identified as an elasmobranch by some respondents. Additionally, discrepancies emerged between responses regarding which shark species were marketed, which suggests a worrying inconsistence and uniformity in knowledge, awareness or labelling practices within the supply chain.

These findings highlighted the urge for a clear and harmonized system to define and identify each species while entering the market, that is the only possibility to support informed consumer choices and sustainable fisheries management. The study advocated for improved labelling regulations, enhanced training for seafood operators, and deeper consumer education to foster more transparent and responsible shark meat consumption.

References

WWF (2021). The shark and ray meat network. A deep dive into a global affair. Available at https://wwfeu.awsassets.panda.org/downloads/a4_shark_2021_low.pdf

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Fish by-products as food ingredients: What do consumers think?

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Abstract

The utilization of marine by-products is a key strategy in the search for sustainable solutions to the growing global problem of food loss and waste. Furthermore, consumers play a fundamental role in promoting more sustainable consumption, as their purchasing decisions can encourage the production and marketing of foods with a lower environmental impact. Given the complexity of the factors that influence people's purchasing choices, it is necessary to analyse consumer behaviour and perception regarding the introduction of by-products in the human food chain. The objective of this work was to determine consumer opinions on the use of fish by-products as food ingredients. To this end, online surveys were conducted using Google Forms. The questionnaire was divided into different sections to assess the importance of different attributes related to sustainability, health, and price at the time of purchase, and to determine the perceived impact of including fish by-products in new food products. Consumers placed a high value on the attributes "healthy" and "price" when purchasing a product. The results of the conjoint analysis showed that of the three factors evaluated (price, inclusion of fish by-products, sustainability label), the least important was the presence or absence of by-products, although the fact that the packaging indicated that it contained by-products had a negative impact on product selection. Regarding the impact of incorporating fishery by-products into food, consumers perceived a positive impact on food waste, price, sustainability, and climate change. However, they estimated it would have a negative impact on safety and nutritional quality. Since consumers place great importance on healthy food and value environmentally friendly products, information campaigns should be conducted on the nutritional benefits and environmental importance of transforming fish by-products into valuable ingredients of new food products.

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