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Smart and eco-innovative SEAFOOD processes and products FOR healthy AGEing

Interreg Atlantic Area
European Regional Development Fund

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Seafood Age

Project funded by the Interreg Atlantic Area Programme through the European Regional Development Fund.
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Smart and eco-innovative SEAFOOD processes and products for healthy AGEing

SEAFOOD-AGE PROJECT
ERDF funding: 2.194.640,95€
Total budget: 2.926.187,91€
Duration: 05/ 2019 | 05/ 2022

SEAFOOD-AGE aims to contribute to healthier ageing and the circular economy paradigm

Prospects indicate that around 2040, the 65+ age group will be in the range of 24% to 45% of the population across the Atlantic Area regions. Malnutrition is a common problem mostly due to changes in eating habits, food choice and difficulties for meal preparation and intake.

Healthy ageing requires a healthy diet, and seafood products provide essential nutrients not always accessible to older adults. With their valuable nutritional properties, marine resources can play a major role in healthier ageing. However, the efficient and sustainable use of marine resources poses further challenges.

SEAFOOD-AGE project is a transnational joint effort aimed at creating solutions towards healthier ageing and a circular economy seafood sector. It will exploit the maritime dimension of the AA regions and will adopt circular economy concepts to generate ready-to-eat seafood for healthy ageing, produce novel eco-packaging and develop a smart label for better quality, safety and minimum food waste.

To reach its goals, the project will:

Design sustainable, healthier, safer, high-quality ready-to-eat (RTE) seafood products to meet the 65+ adults' needs and reduce food loss;

Produce eco-innovative packages exploiting natural resources and by-products to meet 65+ adults' requirements;

Design smart predictive labels to aid retailers to reduce food waste while optimising quality and safety, and to support ageing consumers to make better-informed RTE seafood choices;

Develop competencies for innovation and accelerate the pace of embedding the circular economy principles into the seafood sector.

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DAY 1 - FINAL CONFERENCE

19th October 2022 — **HOTEL Pazo los Escudos**

Welcome at PAZO LOS ESCUDOS HOTEL — 09:15 - 09:30

SEAFOOD-AGE Project — 09:30 - 09:50

Eva Balsa-Canto. *Project coordinator (IIM-CSIC).*

SESSION 1. TECHNICAL RESULTS

NEW HEALTHIER, SAFER AND HIGH-QUALITY RTE SEAFOOD PRODUCTS — 09:50 - 10:50

• Sustainable production of food ingredients

Xosé Antón Vázquez. *Senior Researcher at Institute of Marine Research (IIM-CSIC).*

• Biological properties of ingredients

Rogério Mendes. *Senior researcher at Instituto Português do Mar e da Atmosfera (IPMA), Portugal.*

• Formulation of the RTE product

Carmen G. Sotelo. *Senior researcher at Institute of Marine Research (IIM-CSIC).*

Coffee-break — **10:50 - 11:20**

ECO-INNOVATIVE PACKAGING SOLUTIONS AND FOOD SAFETY — 11:20 - 12:00

• Design and development of an Eco-packaging for the Ready-to-Eat Seafood product

Ina Bremenkamp and Maria J. Sousa Gallagher. *Researcher & PI in Process & Chemical Engineering, University College Cork (UCC), Ireland.*

• Quality and Safety of RTE Seafood products

Marta Lopez. *Senior Researcher at Institute of Marine Research (IIM-CSIC).*

SMART PREDICTIVE LABELLING SOLUTIONS — 12:00 - 13:00

• Molecular methods to identify ingredients in processed seafood

Carmen G. Sotelo. *Senior researcher at Institute of Marine Research (IIM-CSIC).*

• Manufacturing of a smart predictive label

Harri Määttä. *Lecturer at Oulu University of Applied Sciences (Oamk), Finland.*

• Smart predictive labels to improve food quality and safety

Eva Balsa-Canto. *Senior Researcher at Institute of Marine Research (IIM-CSIC).*

Cocktail & Networking — **13:00 - 14:20**

SESSION 2. INDUSTRIAL RESULTS

NEW HEALTHIER, SAFER AND HIGH-QUALITY RTE SEAFOOD PRODUCTS — 14:20 - 15:00

• Production of fish mince in an industrial pilot plant

Juan C. Martín Fragueiro. Gerente de *Organización de Productores de Pesca del Puerto y Ría de Marín (OPROMAR).*

• Value chains for European seaweeds

Julie Maguire. *Manager of Indigo Rock Marine Research Station (IRMRS), Ireland.*

ECO-INNOVATIVE PACKAGING SOLUTIONS AND FOOD SAFETY — 15:00 - 15:40

• Novel eco-packaging solutions

Manuel López Romero. *Technical lead Ooho Project & QSE Manager at NOTPLA, United Kingdom.*

• Microbial ready-to-use kit

Alejandro Garrido-Maestu. *Staff researcher at International Iberian Nanotechnology Laboratory (INL), Portugal.*

SMART PREDICTIVE LABELLING SOLUTIONS — 15:40 - 16:10

• Smart predictive labels in the real-world practice

Harri Määttä. *Lecturer at Oulu University of Applied Sciences (Oamk), Finland.*

Eva Balsa-Canto. *Senior Researcher at Institute of Marine Research (IIM-CSIC).*

Coffee-break — 16:10 - 16:30

SHOWCASE OF PRODUCTS — 16:30 - 17:00

• Seaweed-based packaging for sauces

Manuel López Romero, NOTPLA.

• Real-time demonstration of the smart predictive label

Harri Määttä, Oamk and Eva Balsa-Canto, IIM-CSIC.

• Ready-to-eat seafood prepared by BENBOA

Paco Teira, BENBOA.

CETMAR
CENTRO TECNOLÓGICO DEL MAR

DAY 2 - BROKERAGE EVENT

20th October 2022 — CETMAR

Venue: CETMAR facilities	**10:00 - 10:15**
SEAFOOD-AGE Project briefing (VIDEO) IIM & CETMAR	**10:15 - 10:45**
ROTATING GROUP DISCUSSIONS	**10:45 - 11:30**

Table 1: Ready-to-eat seafood product meeting the senior adults' needs based on circular economy principles.

Table 2: Food safety and innovative packaging solutions.

Table 3: Smart predictive label to reduce food waste while optimising quality and safety.

Coffee-break	**11:30 - 12:00**
BILATERAL MEETINGS	**12:00 - 13:30**

Researchers and industry will be available to discuss further details about the solutions reached in SEAFOOD-AGE project. Networking and B2B meeting points will also be available.

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Xosé Antón Vázquez
Senior Researcher at Institute of Marine Research (IIM-CSIC).

FINAL CONFERENCE ABSTRACTS

Sustainable production of ingredients

Xosé Antón Vázquez. *Senior Researcher at Institute of Marine Research (IIM-CSIC).*

The first step carried out to achieve the objectives established in the SeaFood Age project dealt with the optimal and sustainable production of the necessary ingredients for the preparation of a ready-to-eat food, based on the muscle of discarded fish species, and enriched in bioactive compounds and high quality fish oil. To meet this initial goal, several physicochemical and/or enzymatic processes and stages were developed aimed at: 1) the mechanical separation of the skin and bones of fish discards from the muscular material (fish mince); 2) the efficient production of enzymatic hydrolysates (FPH) with remarkable biological activities (antioxidant, antihypertensive, antidiabetic) from different fish species and substrates; 3) the efficient recovery of oils rich in omega-3, concomitant with the production of FPH, from the by-products (heads and skins) generated in obtaining fish mince. Thus, our results have led to the definition of the optimal operations and parameters for the production, on a semi-pilot scale, and supply, to the partners that manufacture the fish fillets and meatballs, of the following selected ingredients: mince from Atlantic horse mackerel, pouting and gurnard, FPH of head horse mackerel, and oils from heads and skins of gurnard and Atlantic horse mackerel. We hope that our proposal can help with the fulfilment of the EU landing obligation, the maintenance of a respectful and sustainable fishing activity, and the generation of new functional foods specially designed for healthy ageing.

Rogério Mendes
Senior researcher at Instituto Português do Mar e da Atmosfera (IPMA), Portugal.

Biological properties of ingredients

Carla Pires, Maria Sapatinha, Narcisa Bandarra and Rogério Mendes*
Instituto Português do Mar e da Atmosfera (IPMA), Portugal.

Fish discards and by-products can be transformed into high value-added products such as fish protein hydrolysates (FPH) containing bioactive peptides. Seaweeds are also well documented in literature as a source of bioactive compounds. Thus, for selection of ingredients with the best biological properties for older adult, the objective of IPMA's team in the project was to evaluate the biological activities (antioxidant, anti-hypertensive and anti-diabetic) of (i) hydrolysates obtained from different parts (whole fish, skin and head) of the most recurrently discarded fish species in trawler fisheries in North-West Spain: blue whiting (Micromesistius poutassou), Atlantic horse mackerel (Trachurus trachurus), gurnard (Trigla spp.), pouting (Trisopterus luscus), red scorpionfish (Scorpaena scrofa) and four spot megrim (Lepidorhombus boscii) and (ii) of Alaria esculenta extracts prepared by enzymatic and ball milling-assisted methods and also with hot water . All FPH exhibited antioxidant activity and those obtained from Atlantic horse mackerel and gurnard heads presented the highest EC50 values. The anti-diabetic activity was relatively low but all FPH had high ACE inhibitory activity. Regarding Alaria esculenta study, the enzyme-assisted extraction was the most effective allowing to obtain the highest yields, and highest phenolic and flavonoids content.

In general, extracts prepared with Alcalase exhibited the highest biological activities. Considering these activities, the hydrolysates prepared from gurnard heads and A. esculenta extracts prepared with Alcalse were selected as ingredients to be incorporated in the ready-to-eat seafood product and in sauce that accompanies this product.

(*speaker)

Ina Bremenkamp
Researcher in Process & Chemical Engineering, University College Cork (UCC), Ireland.

Maria J. Sousa Gallagher
Senior Researcher in Process & Chemical Engineering, University College Cork (UCC), Ireland.

Design and development of an Eco-packaging for the Ready-to-Eat Seafood product

Ina Bremenkamp and Maria J. Sousa Gallagher, Process & Chemical Engineering, University College Cork (UCC), Ireland

Packaging is an integrated component of the food process. It has a wide range of roles, from protecting quality and safety, transport, being user-friendly, providing product information and/or acting as communicator between producers and consumers. Rethinking packaging, for recyclability, circularity and sustainability is required to overcome the current packaging challenges, e.g. the dependency on fossil materials or waste management.

Edible coatings are alternative eco packaging systems based on biobased materials. During the Seafood-Age project, UCC focused on the design and development of edible coatings for the Ready to Eat (RTE) seafood product, and additionally a packaging system consisting of an edible coating and an outside layer was investigated. Edible coatings have advantages in terms of food safety and quality and can reduce food waste. Edible coatings are an invisible layer around the product providing protection function to the product. Edible coatings can be sourced from natural polymers, as marine polymers, i.e., chitosan and alginate. The coating formulation was tailored for the product of interest, taken into consideration the critical quality and safety characteristics of this product, and it's processing. Additionally, as a coating often cannot provide all the required packaging functions on its own, a packaging system consisting of an edible coating and an outside layer was also developed and validated.

UCC will present the used strategy for the design, development and validation of an eco-food packaging system for the RTE seafood product. Circularity and sustainability were considered on the production of the eco-food packaging system. The edible coatings were shown to be a successful eco-food packaging strategy and could be one step forward towards improving sustainability of food packaging.

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Marta López Cabo
Senior Researcher at Institute of Marine Research (IIM-CSIC).

Quality and Safety of RTE Seafood products

Marta López Cabo, Institute of Marine Research (IIM-CSIC), Spain.

The quality of the lab and industrial-scale RTE seafood products developed following circular economy principles in the SEAFOOD project were assessed in terms of shelf-life and bacteriome evolution during storage in order to identify the organisms (species) responsible for spoilage (SSO). Microbial, chemical, and sensory analyses permitted to set the shelf-life limit of these products between 9 and 12 days when stored at 5°C, depending on the processing.

Metabarcoding outcomes identified Sporosarcina (aquimarinum) main potential specific spoilage organism (SSO) in this type of products. Regarding safety, challenge studies against Listeria monocytogenes permitted to classify the products into the category 1.2., in which a limit of 100 CFU/g must not be exceeded in products placed on the market during their shelf-life.

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Carmen G. Sotelo
Senior researcher at Institute of Marine Research (IIM-CSIC).

Molecular methods to identify ingredients in processed seafood

Sánchez A., Correa B., Sotelo C.G.* Institute of Marine Research (IIM-CSIC), Spain.

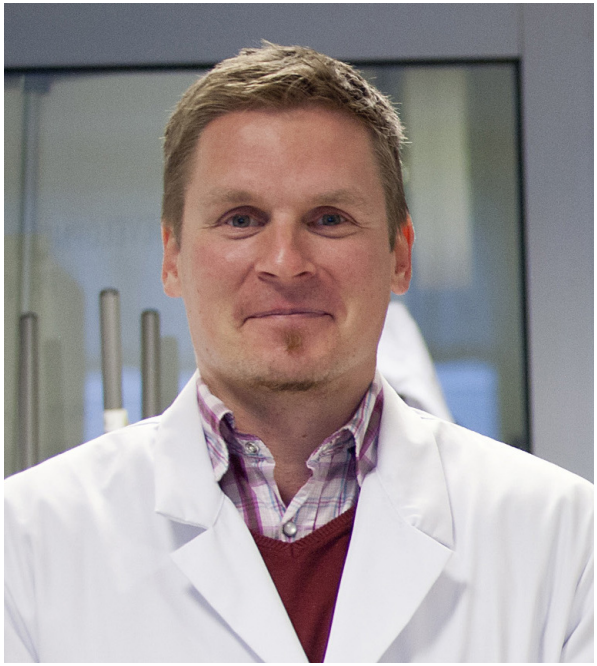
Processed seafood has gained popularity among consumers during the last decades mainly because it provides a convenience meal with a high nutritional value. As a consequence, a wide variety of products have been placed in the market by the industry, with different ingredients and claims, making necessary to establish labelling regulations in this product category.

The project SEAFOOD-AGE has investigated the application of a Next Generation Sequencing (NGS) approach to analyse the ingredients present in processed seafood, focusing in Ready to Eat (RTE) and Ready to Cook (RTC) seafood products. For that, an evaluation of RTE and RTC seafood products present in the market was performed, finding 117 products that were classified in 6 categories: precooked seafood, battered fish, sausages, fish burgers, pate, Croquettes/fishballs.

Two mitochondrial DNA regions, COI and 16S, were selected as universal molecular markers for ingredients of animal origin, while one nuclear gen, ITS1, for the identification of vegetable species.
NGS-metabarcoding sequencing assays and bioinformatic analysis with a selection of reference (DNA and tissue mixtures) and commercial samples were performed for testing the ability of this methodology for the identification and quantification of ingredients in RTE and RTC seafood products. The identification of species present in the reference mixtures samples, as well as the main ingredients of commercial RTE/RTC seafood product, was successful.

However, although accurate quantification results of the ingredients was obtained in mixtures of DNA of reference samples, in the case of tissue mixtures samples quantification results were not satisfactory, probably due to differences in the DNA copy number in different species.

(*speaker)



Harri Määttä
Lecturer at Oulu University of Applied Sciences (Oamk), Finland.

Manufacturing of a smart predictive label

Harri Määttä, Oulu University of Applied Sciences (Oamk), Finland.

Printed electronics is a technology in which electronic components and systems are manufactured utilizing traditional printing methods. Printing is an additive method in which a certain amount of functional material is accurately added to the substrate, as opposed to removal methods in traditional electronics manufacturing where excess material is etched away.

The method achieves a variety of benefits, such as the cost-efficient manufacturing in high volumes and the reduced need for materials. Very thin, flexible, stretchable and even biodegradable materials can be used as the substrate. This makes it possible to implement more environmentally friendly, sustainable and completely new types of components and devices, with lower manufacturing costs. Seafood Age smart predictive labels take the benefit of using printed electronics technologies to enable the thin and flexible form factor of structure.

Manufacturing of a smart predictive label using printed electronics techniques at Oamk´s printed electronics R&D and small scale manufacturing laboratory PrinLab will be introduced using material from actual manufacturing processes, such as table top screen printing. Manufacturing processes used at PrinLab and presented here are lab scale, but can be scaled up to mass manufacturing.

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Eva Balsa-Canto
Senior Researcher at Institute of Marine Research (IIM-CSIC).

Smart predictive labels to improve food quality and safety

Eva Balsa-Canto, Institute of Marine Research (IIM-CSIC), Spain.

Ready-to-eat (RTE) foods are increasing their market share. Refrigerated storage and distribution are the most widely used methods for controlling microbial growth in RTE products. During storage, the microbial load in the products is affected by many factors. However, the occurrence of temperature abuses has a critical impact on food safety and quality. Higher temperatures lead to uncertainties concerning microbial safety, as food-borne pathogens might be present in the product; but also shelf life due to the potential spread of spoilage microorganisms. Tracking of temperature histories throughout the supply chain enables the detection of possible abusive conditions, which may contribute to shelf-life reduction (and thus food waste) or foodborne outbreaks.

In this work, we present a smart predictive label (SPL) designed to ensure the integrity and wholesomeness of RTE products. SPLs guarantee temperature control and automatically detect and inform about safety issues or quality deterioration. To do so smart labels combine hardware (temperature) sensors with software sensors (predictive models) to make predictions about quality and safety risks allowing sending alarms or to re-evaluated shelf life.

This talk presents how to implement the software sensor: the type of predictive models that are being used, how to calibrate the sensors for specific RTE products, and how to use them in real practice.

Juan Carlos Martín Fragueiro
Gerente de *Organización de Productores de Pesca del Puerto y Ría de Marín (OPROMAR).*

Production of fish mince in an industrial pilot plant

Juan Carlos Martín Fragueiro, Organización de Productores de Pesca del Puerto y Ría de Marín (OPROMAR), Spain

The Organización de Productores de Pesca del Puerto y Ría de Marín (OPROMAR) is a transnational organization that brings together 21 trawlers, 17 longliners and 4 purse seiners that catch species such as swordfish, Patagonian toothfish, blue shark, mackerel, horse mackerel or megrim.

Since the entry into force of the Landing Obligation, all individuals of species subject to TACs or quotas must be kept on board and landed at port, which has promoted the development of projects to enhance the value of species that were previously discarded.

The selection of species for obtaining processed products of high nutritional value and quality is based on criteria such as the regular supply of raw material, the nutritional, physical-chemical and organoleptic properties of the product or the economic viability of the valorization option.

The production of fish mince is the first step in the preparation of ready-to-eat products. This process produces fish muscle blocks and by-products that are subsequently treated to obtain protein hydrolysates and fish oils that can be used to enrich the final product.

Julie Maguire
Manager of Indigo Rock Marine Research Station (IRMRS), Ireland.

Value chains for European Seaweeds

Julie Maguire, Indigo Rock Marine Research Station (IRMRS), Ireland

Global macroalgal production and demand began to take off in the 1950's, increasing exponentially in the past 30 years and reaching over 35 Mt in 2019. Global production is mainly based on cultivation (97% in 2019) from Asia. Europe still lags behind in terms of seaweed production with only 0.8% of world production originating from Europe, the vast majority being wild harvested. However, there is considerable potential for European production to increase significantly. All marine waters in the European EEZs have been assessed as "high opportunity" to develop seaweed aquaculture. The demand for seaweed in Europe is growing at 7-10% per annum. Most of this demand is satisfied from importing seaweed from Asia. As for the uses for seaweed, 70% of global seaweed is used in food production. Alginate, carrageenan and agar use 15-20% of the global harvest. In the past ten years >2,600 new products containing seaweed were introduced into the European market. The presentation will outline the primary production and processing of seaweed in Europe. The opportunities and bottlenecks for expansion are discussed along with traditional and novel products and processes.

Manuel López Romero
Technical lead Ooho Project & QSE Manager at NOTPLA, United Kingdom

Novel eco-packaging solutions

Manuel López Romero, NOTPLA, United Kingdom

Single use eco-packaging solutions made from seaweed to fight the plastic issue without changing consumer behaviours. In particular, the packaging we were developing in Notpla for the sauces of the SeafoodAGE project. At Notpla we are on a mission to make packaging disappear. To replace conventional food packaging by pioneering the use of seaweed as an alternative to single-use plastic.

Notpla materials are made from one of nature's most renewable resources, seaweed. Seaweed is one of nature's most renewable resources. Globally abundant and fast-growing, it doesn't require freshwater, land or fertiliser. This inconspicuous sea vegetable is one of our greatest weapons against climate change, fighting ocean acidification and effectively absorbing carbon.

The Notpla sachet, Ooho, used to encapsulate the sauces of the SeafoodAGE project. It's an edible bubble designed for liquids. Notpla Ooho is the revolutionary solution to single-use plastic packaging for liquids. Inspired by nature it's plastic-free and biodegrades naturally.

Alejandro Garrido-Maestu
Staff researcher at International Iberian Nanotechnology Laboratory (INL), Portugal.

Microbial Ready-To-Use kit

Development of a Ready-To-Use kit for the detection of Listeria monocytogenes in fish-based products.

Alejandro Garrido-Maestu, Marta Prado, Food Quality & Safety Research Group. International Iberian Nanotechnology Laboratory (INL), Portugal.

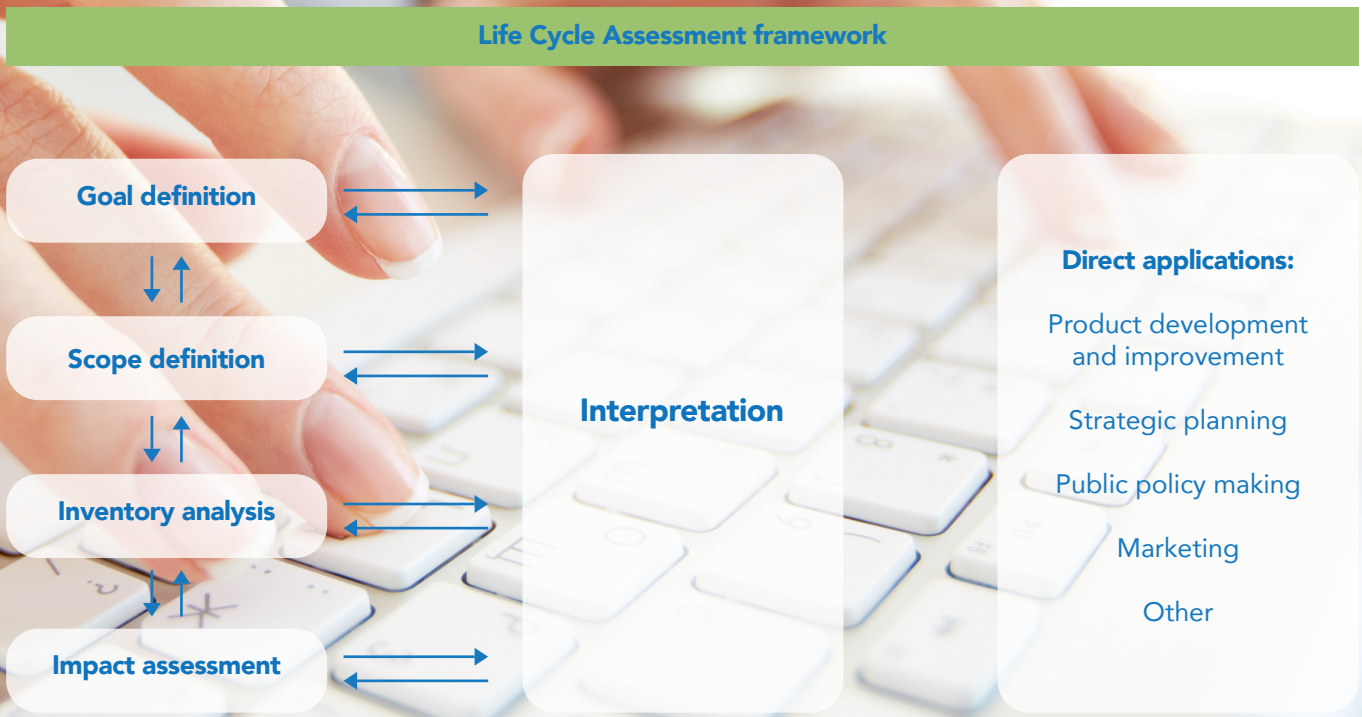
Listeria monocytogenes is a major foodborne pathogen which is capable of surviving under harsh environmental conditions. Humans get infected by consuming contaminated foods where L. monocytogenes can survive, and even grow under typical preservation conditions such as refrigeration. For this reason ready-to-eat (RTE) foods are of particular concern and their safeness must be carefully assessed. In the Seafood Age project a novel fish-based RTE product was developed. It was determined that it may support the growth of L. monocytogenes thus a ready-to-use kit for the detection of this pathogen was also developed. The kit was designed in order to be simple to perform and economic and consisted on three main steps: sample enrichment, DNA extraction and pathogen detection by real-time PCR. For the enrichment different broths were evaluated and ONE Broth Listeria, from OXOID, was identified as the most suitable option as allowed to simply culture the bacteria over 24 hours without additional manipulation or the need of secondary enrichment steps. For the DNA extraction different commercial kits were compared, and finally optimal results were obtained with a simple thermal lysis protocol based on the usage of a chelating resin (Chelex 100, Bio-Rad) allowing to reduce the cost, time and complexity of this step. Finally, a previously published real-time PCR assay was implemented in the method being completed in roughly 20 minutes.

An interlaboratory validation study was organized in order to assess the performance of the ready-to-use kit. No significant deviations were identified being possible to accurately detect L. monocytogenes at all the concentrations tested in the study.

Life cycle assessment or LCA

is a methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service.LCA is a powerful decision support tool, complementing other methods, which are necessary to make consumption and production more sustainable.

In the framework of SEAFOOD-AGE, The LCA has been done by INXENIA DESARROLLOS TECNOLOGICOS S.L. following the main requirements of the ISO 14040 and 14044 standards:



The Goal is:

To identify environmental hot spots, with the objective of prioritizing improvements.To compare with similar products.

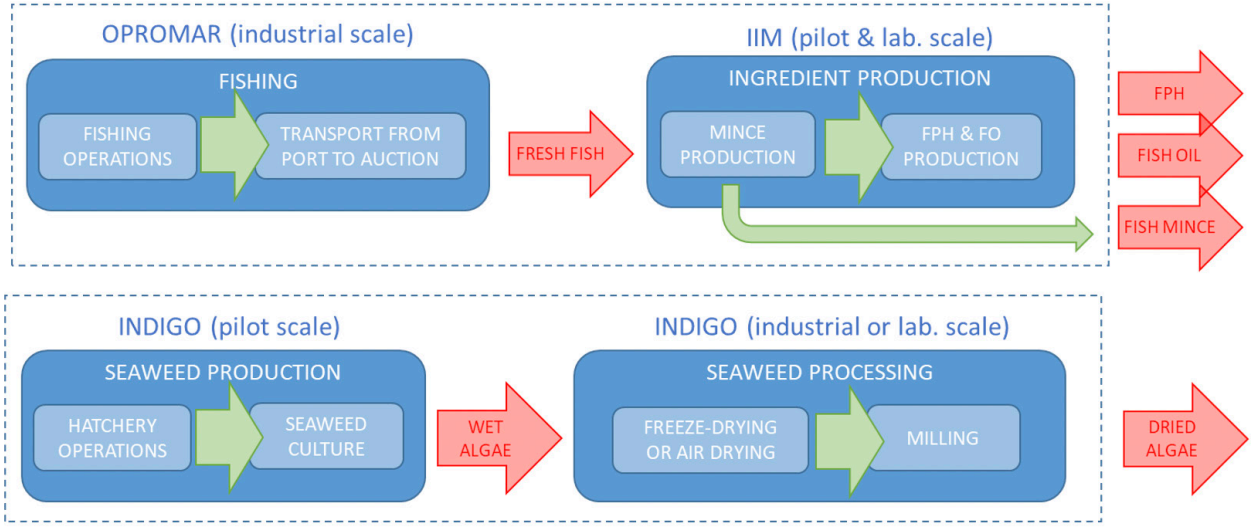
Foreground data was provided by the partners involved in the processes studied at lab scale, pilot scale, pre-industrial or even industrial scale.

Background data as well as methods for the impact category analysis (as IPCC 2013 GWP 100a and ReCiPe 2016 Midpoint (H) methods) were provided by Simapro, the world's most widely used LCA software.

Hotspots of each case study have been identified. Special attention was paid to climate change, but other impact categories were also analysed.

Limitations of this study:
Certain transport, use of containers, cleaning and cold storage have not been included.
Lack of information about ingredients or missing inventories.
Assumptions and hypothesis have been taken.
Results can vary when upscaling.

Ready to eat product (BEMBOA) - Picture by CETMAR.

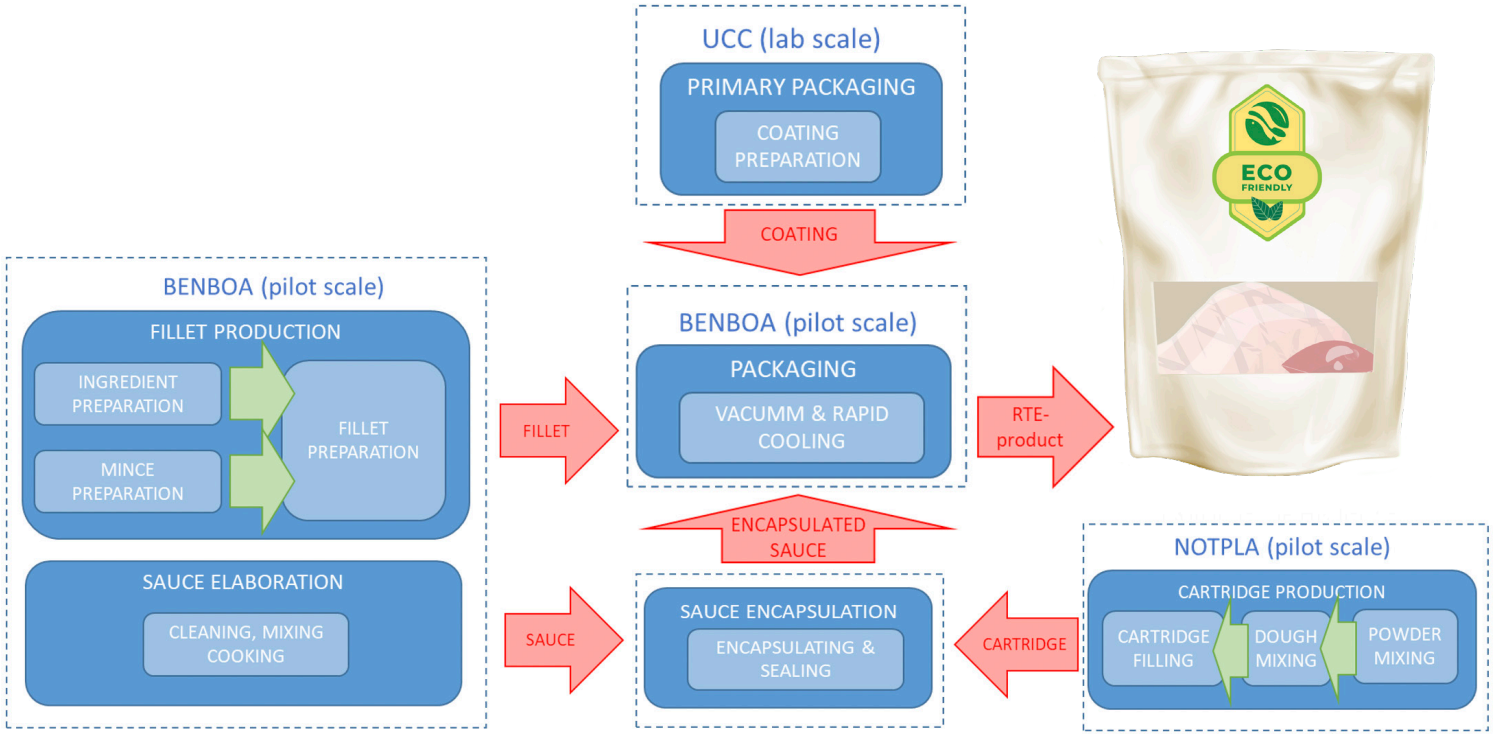


Ready to eat product

Functional unit:

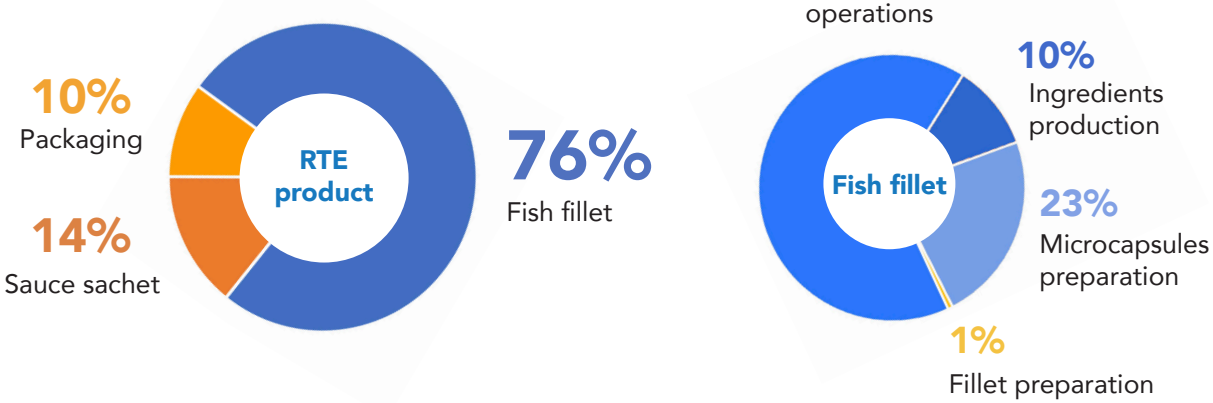
A RTE product consisting of:
A coated 95g fillet (made of fish mince with 8% of FPH/FO microcapsules).
An edible and biodegradable sachet containing 25g of sauce.
Vacuum packed and thermosealed with laminated film.

Being **SEAFOOD-AGE** a project focused on the demonstration of several developments at different scales, each partner's case study was studied separatedly and with a cradle to gate approach.

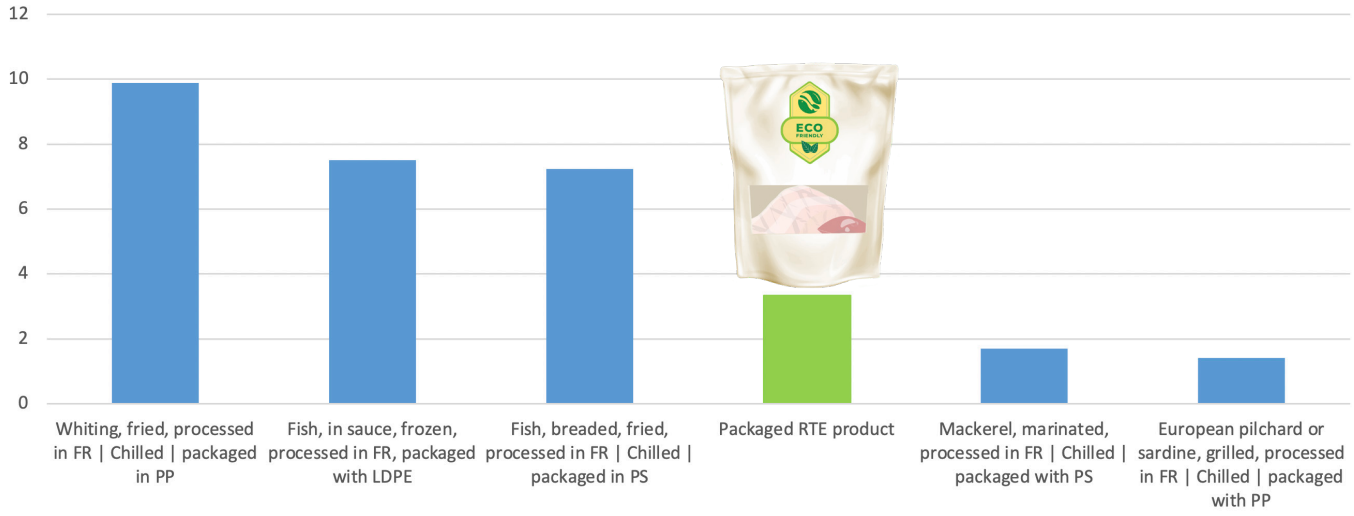


0.43 kg CO2 eq/ packaged RTE product

Contributions to the Carbon Footprint



Comparison with similar products' carbon footprint

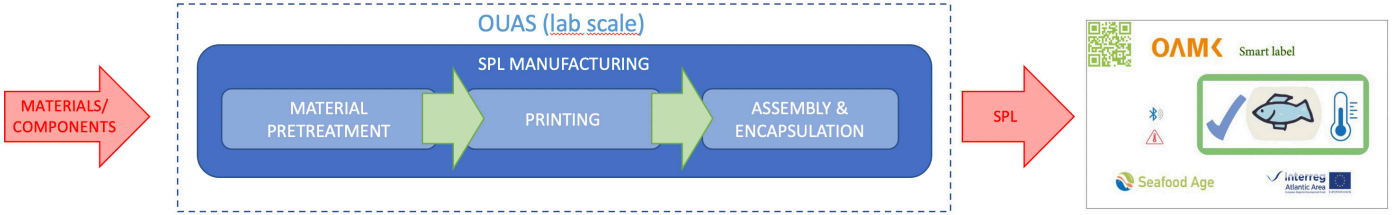


Source: AGRIBALYSE 3 Datasets

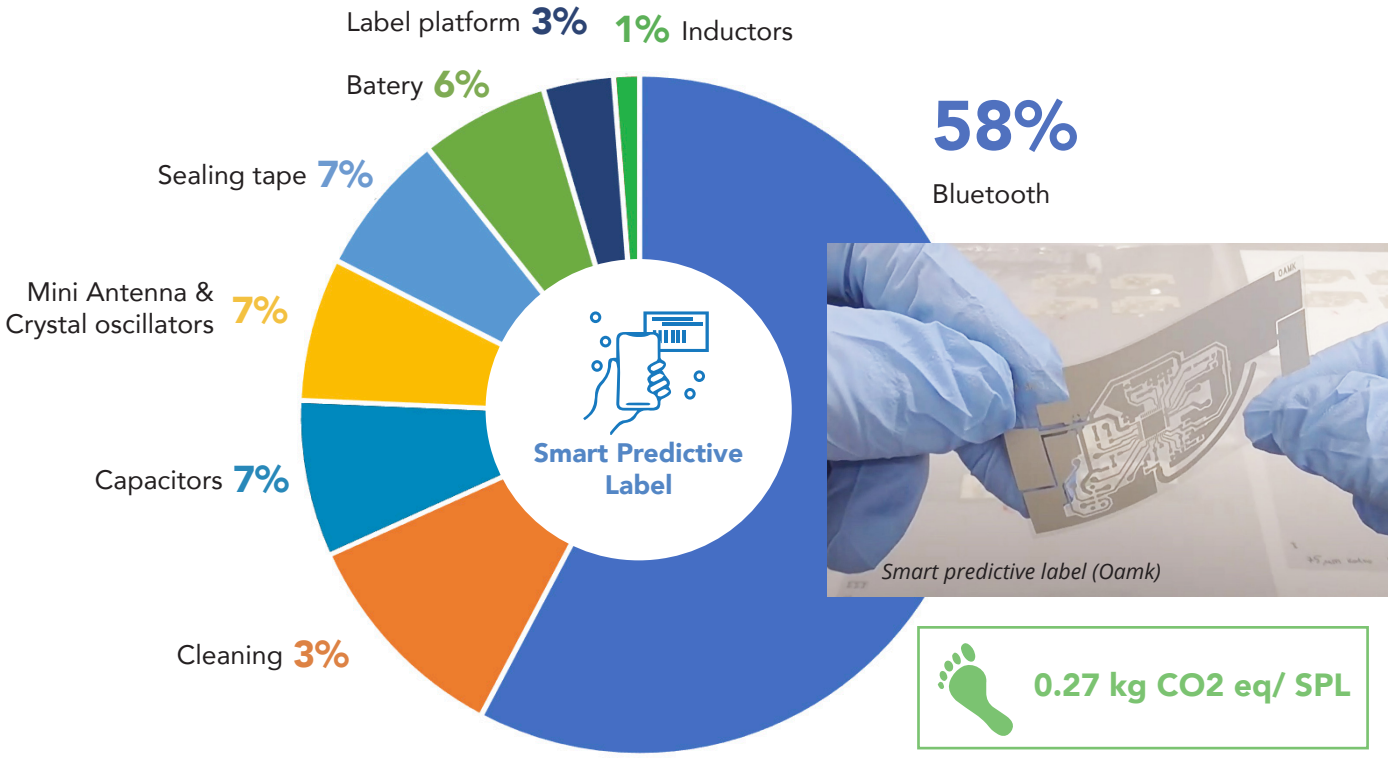
Smart Predictive Label

Functional unit:

A Smart Predictive Label (SPL) with integrated printed temperature sensor and battery as well as a Bluetooth device.



Contributions to the Carbon Footprint



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