FISH chitinolytic biowastes FOR FISH active and sustainable packaging material

FISH4FISH

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List of Contents

- Introduction 1
- Partnership 2
- Project Target 3
- The FISH4FISH project in a nutshell 4
- Blue Labs 5
- Pilot Development 6
- Environmental assessment (LCA) 7
- Economic assessment (LCC) 11

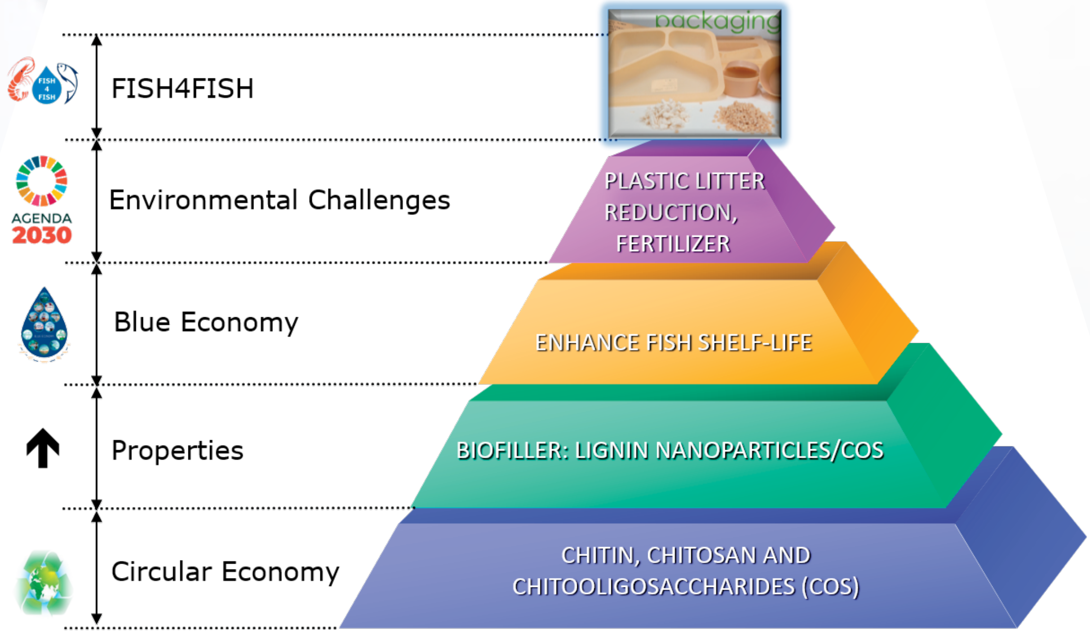
Introduction

The fish industry has a strong need to improve marketability and to extend the shelf-life of fresh fish, shortened by microbial spoilage. At the same time, the size of this industry is so big that it produces huge amounts of plastic containers and more than 10,000 tons/year of shellfish food waste. Packaging plays a critical role in the fish supply chain and can be part of the solution to tackle food waste.

The FISH4FISH project aims to produce active and sustainable packaging material based on chitinolytic derivatives, using marine biomass wastes. Such packaging, at the end of life, can be used as fertilizer and microbial preservatives for plants.

Chitin obtained from marine biowastes will be treated to obtain chitosan and chito-oligomers. Lignin nanoparticles will be functionalized with chito-oligosaccharides and used as active biofiller in the preparation of the new polymeric materials.

In this way, renewable resources are exploited in a sustainable manner, promoting bio-based, environmentally friendly and beneficial technologies, and create high-performing materials for a wide range of applications. Fishing and distribution companies will be able to gain competitive market positions and to avoid the use of plastics.



The FISH4FISH project was funded under the european call EMFF-BlueEconomy 2018 for the Topic Blue Labs: innovative solutions for maritime challenges. The project works at the inteface between research and commercial exploitation in support of a sustainable blue economy, preserving marine resources and ecosystems.

Partnership

The project is born as an Italy-Spain partnership covering the Mediterranean and Atlantic sea basins, following the sea basin strategies reported in:

https://oceans-and-fisheries.ec.europa.eu/ocean/sea-basins/eu-sea-basins_en

and in the 2018 report on blue strategy economy:

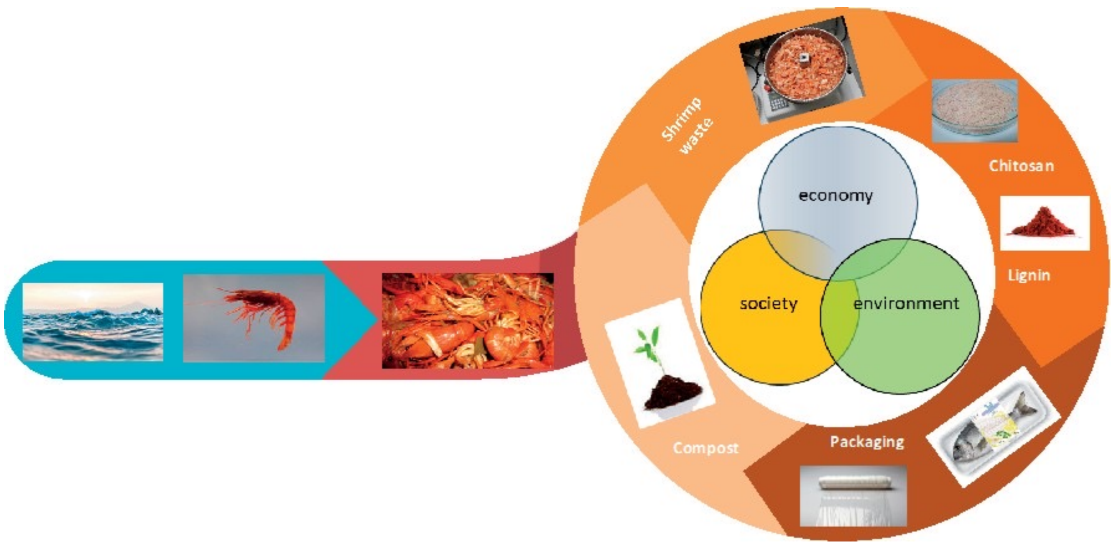
https://op.europa.eu/en/publication-detail/-/publication/79299d10-8a35-11e8-ac6a-01aa75ed71a1

Project target

- Active packaging biocomposite to reduce microbial spoilage to enhance fish shelf-life
- High perfomance packaging (mechanical, thermal and barrier properties)
- Biodegradable and compostable to be used as fertilizer and microbial preservative for plants

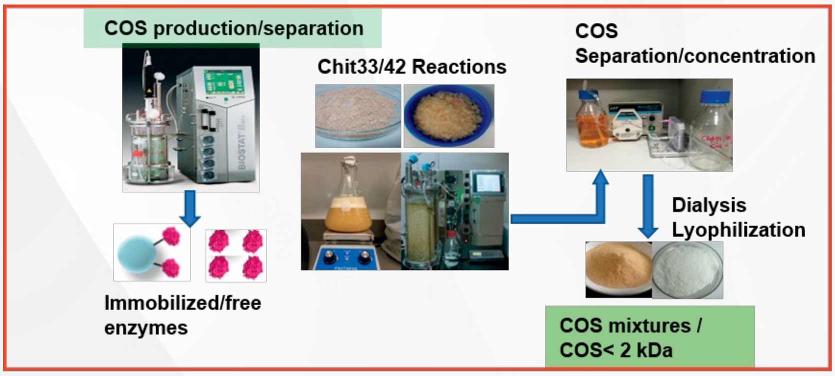
The FISH4FISH project in a nutshell

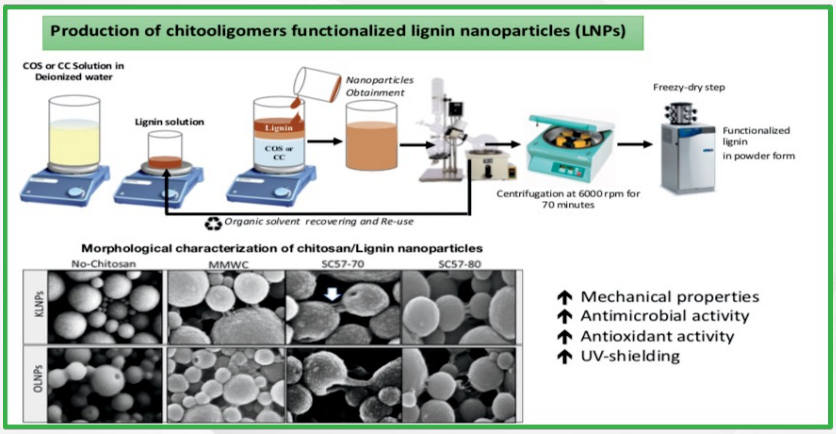
- Reduction of plastic pollution from coasts and seas, preservation of marine environment (2018 blue economy report, Horizon Europe Mission – Healthy Ocean)
- New value to the fish industry waste
- Enhance competitiveness of fish-processing industry
- Reduction of food waste
- Contribution to soil health for a high quality compost (Horizon Europe Mission – Healthy Soil and Food)
- Implementation of Sustainable Development Goals (SDGs)

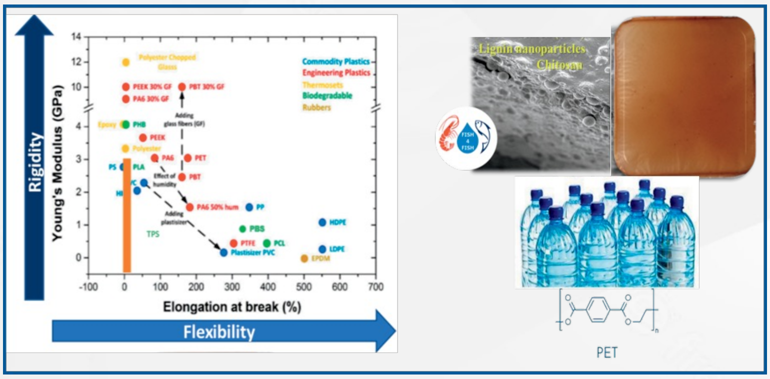


Blue Labs

Schematic representation of the different steps for the production at Lab scale of the FISH4FISH biocomposite

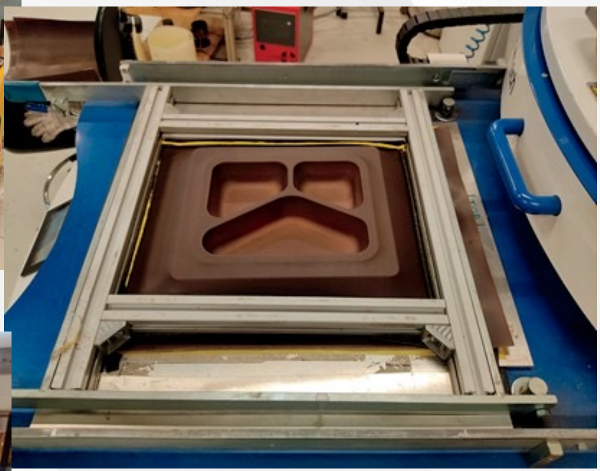






Pilot Development

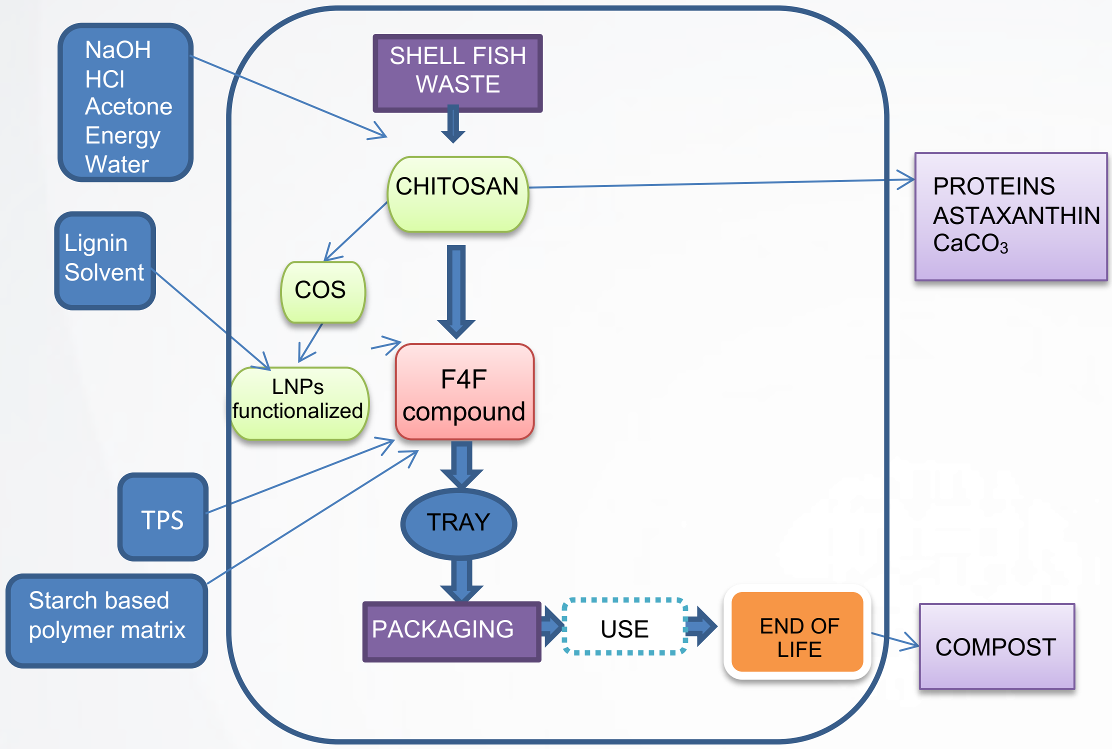
Production at pilot scale of the trays and film prototypes



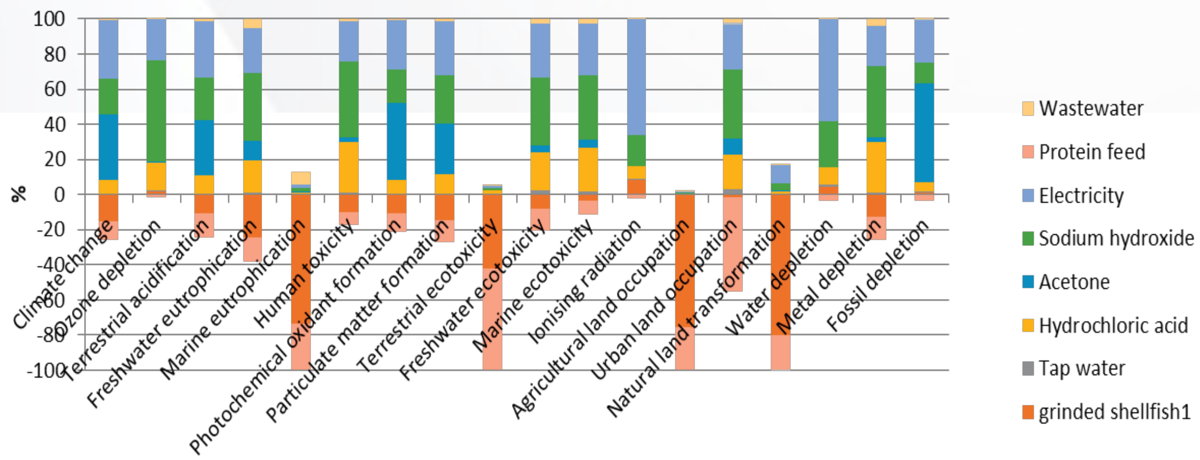
Environmental Assessment

Life Cycle Analysis (LCA)

System boundaries of the LCA for the production of the sustainable packaging from shell fish waste



Environmental profile of chitosan production



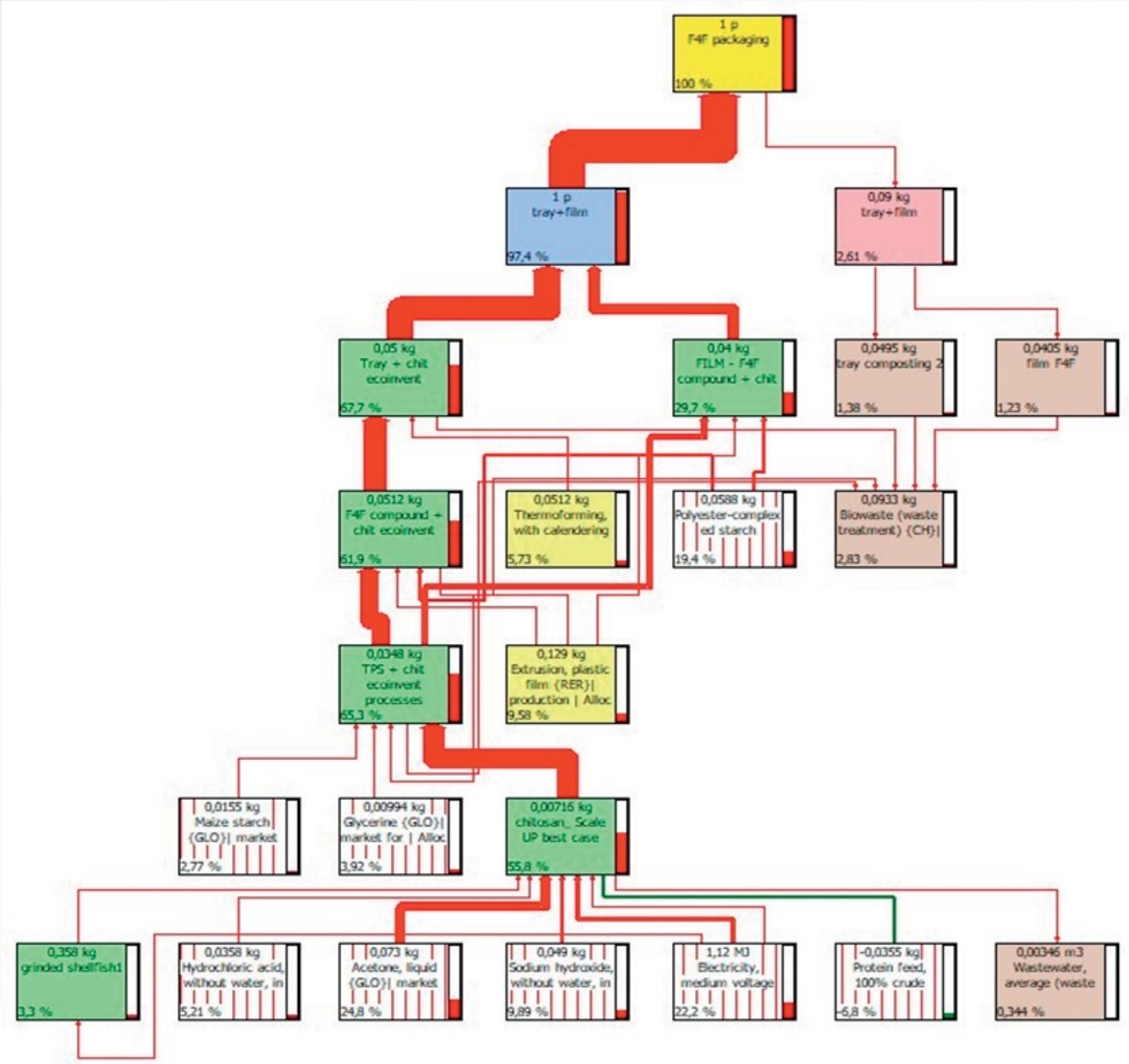
1 kg 'chitosan'; Method: ReCiPe Midpoint (H) V1.10/Europe Recipe H/ Characterization

Chemicals and electricity are responsable of the environmental impact of chitosan. Shrimp shell waste and proteins recovered from the process give environmental advantages in many impact categories.

Biopolymer formulations usually include several components such as the main matrix, the secondary polymers and the additives. For the FISH4FISH compound a starch-based polymers was selected among commercial bio-polymers to reach benchmark qualitative requirements, such as home compostability, biobased origin and food contact certification.

F4F packaging: life cycle network

Functional Unit 1 piece of packaging (tray = 50g + film =40 gr)



Kg CO_2eq emitted from 1 packaging (tray+film) = 0.5

Kg Oileq emitted from 1 packaging (tray+film) = 0.17

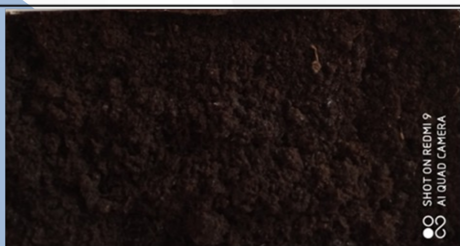
END of Life

Comparing the Global Warming Potential (GWP) for End of Life for F4F packaging, composted in industrial plant, with a traditional fossil based plastic packaging, disposed 50% in landfill and 50% in incinerator as a result 30% of CO_2 eq is saved for F4F

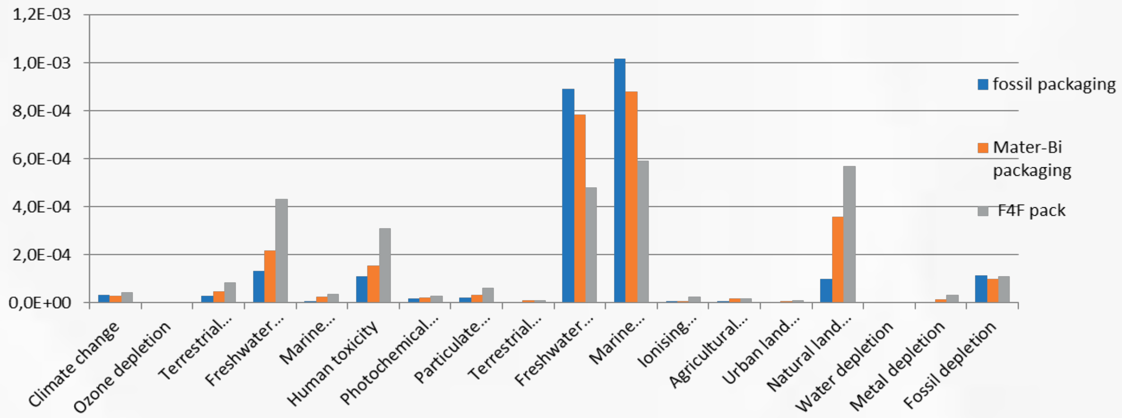
GWP 100 years: Kg CO_2 eq

Comparison between 1piece 'F4F packaging' and 1 piece 'fossil based packaging'. Method :IPCC 2013 GWP 100 yr V1.00/Characterization

Compostability is confirmed by Biodegradability test ISO 14855 and Disintegration test ISO 20200

Week	Film Disintegration	Trays Disintegration
0		
8		
12		
Degreee of disintegation, D(%)	99,51	98,09

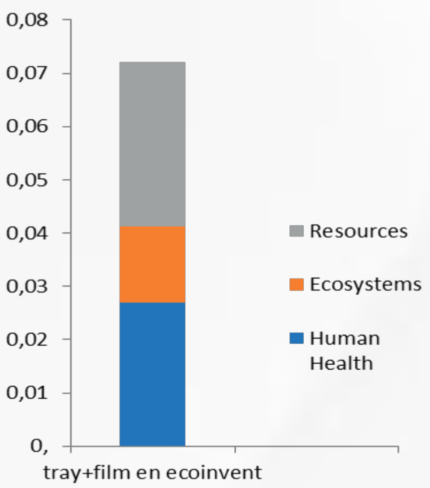
F4F packaging Vs other packaging materials



Comparison of 1 p 'fossil packaging', 1 p 'Mater-Bi packaging' e 1 p ' F4F pack'; Method: ReCiPe Midpoint (H) V1.10 / Europe Recipe H / Normalizzation

The comparison with most used fossil and biobased foodpackaging currently on the market, is not yet favorable but, it must be taken into account that the LCA study does not consider that PET, PP polymer and also Materbi are the result of a mature technology optimized at industrial level, whereas F4F packaging is at an early stage of development, and its production is still at pilot scale.

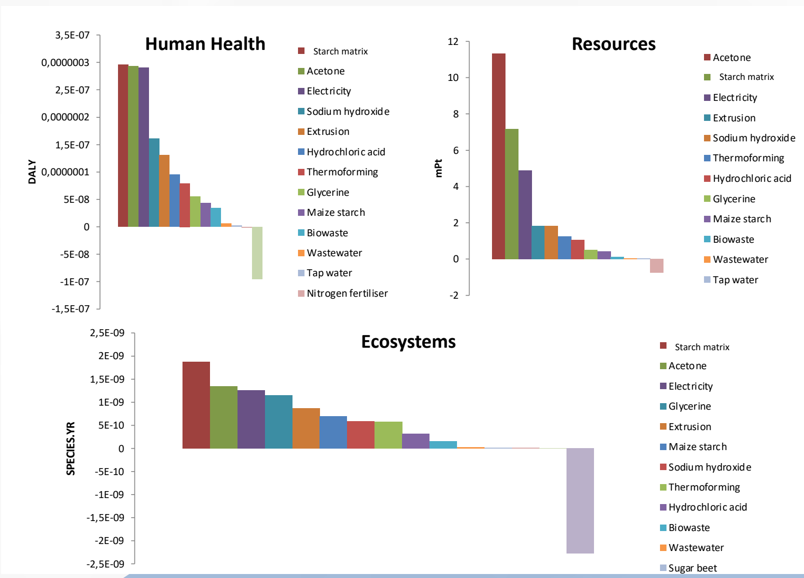
Hotspots and future development



“Single point” representation of the impact of 1 piece of packaging analysed with the Recipe Endpoint Method. Endpoint indicators show the environmental impact on three higher aggregation levels called “areas of protection”:

1) effect on human health;
2) biodiversity;
3) resource scarcity.

The main hotspots common to the three areas are: starch based polymer matrix, acetone and electricity.



Analysing 1piece 'F4F packaging'; Method ReCiPe Endpoint (H) v1.10 / Europe ReCiPe H/A / Damage assessment

Areas of future improvement:

- Apply green technologies in chitosan extraction to avoid the use of NaOH and HCl
- Recovering high value byproducts (astaxanthin, $CaCo_3$)
- Chemicals and water recycling
- Improve energy efficiency

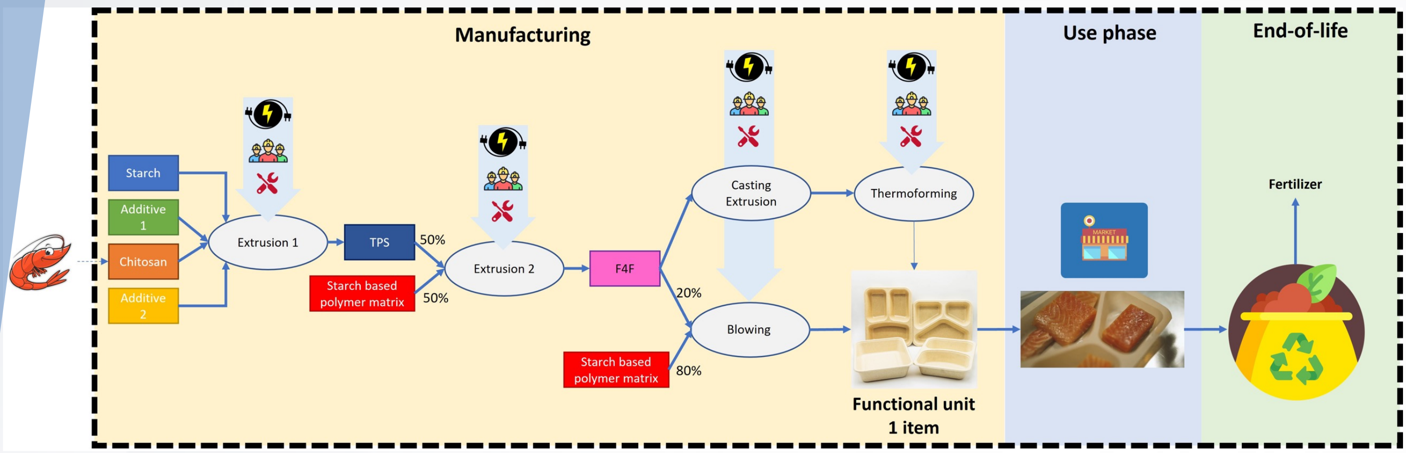
Up scaling from pilot to industrial scale.

Economic Assessment

Life Cycle Cost (LCC)

• System boundaries and LCC model

• The system boundaries of the study include the production of the film and of the tray, which represents the functional unit of the study, as well as the use and end-of-life stages



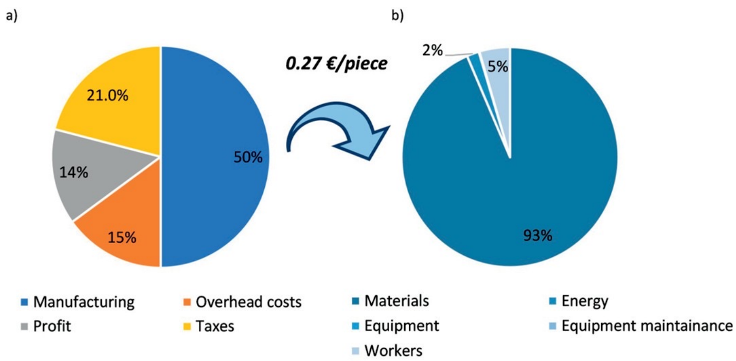
Inputs:

Blend of 5 bio-plastic materials, including chitosan extracted from waste shrimps.

Production line composed of 4 steps requiring the consumption of energy, the employment of operators, and the purchase and maintenance of equipment.

The electricity demanded to produce 1 tray is 0.25 kWh.

The food packaging product fabricated in Fish4Fish has a price that equivales to 0.27 €/piece, which is, as expected, higher than the cost of a standard polyethylene food packaging product, which is around 0.04 €/piece.



Items contributions to a) the final price of the packaging product and b) to the manufacturing cost. Raw materials largely represent the main cost item of the manufacturing cost.

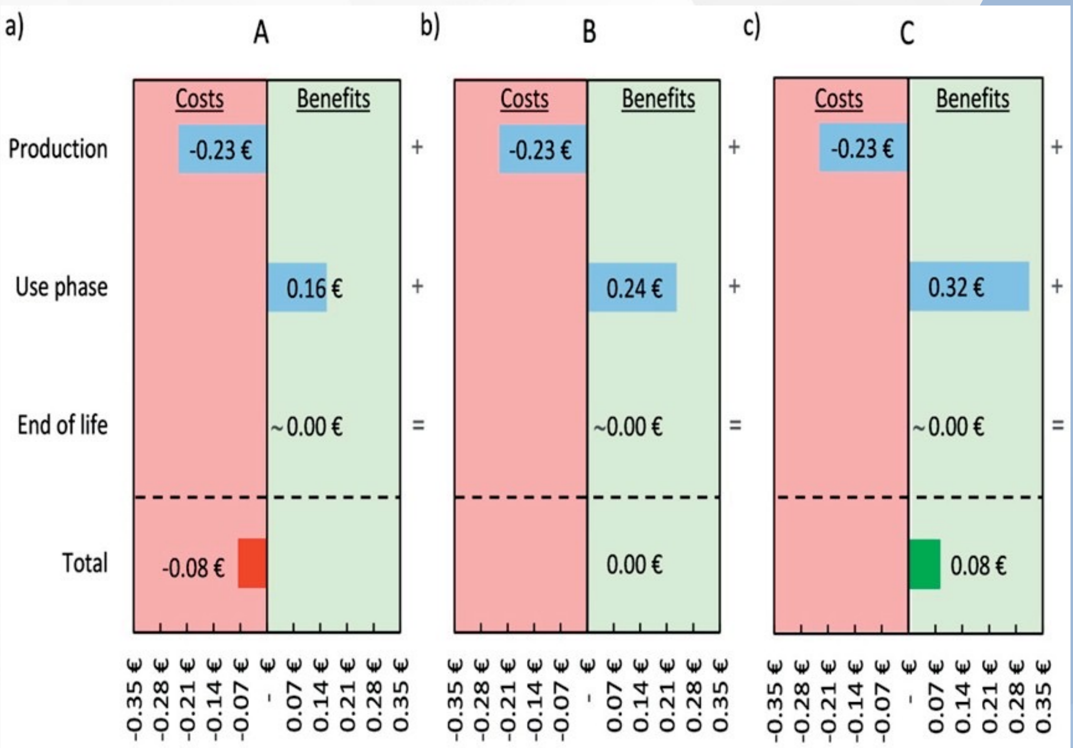
Following a life cycle perspective, the economic competitiveness of the product shall be evaluated considering also the potential advantages occurring during the use and end of life stages.
Due to the active components chitosan and functionalized lignin nanoparticles, the adoption of the F4F packaging material allows to extend the durability of the fish contained inside it, thus determining an increase of sales. A specific case study is designed to evaluate such economic advantage, considering Italy as the reference location.

Assuming that using the selected fish trays allows to extend the durability of the product (+30%)

scenario A, the analysed packaging product allows to reduce the percentage of expired salmon wasted by the market from 5.0 % to 3.5 %. NON ECONOMICAL CONVENIENT

scenario B, the percentge of expired salmon wasted using a polyethylene product is 7.5%; COMPETITIVE

scenario C, the amount of waste of salmon produced by the marked is 10% of the purchased fish. CONVENIENT



Economic life cycle costs and benefits of the Fish4Fish packaging product compared to a traditional polyethylene food tray considering the scenarios a) A, b) B. and c) C.

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