



# SEAREFINERY

**BlueAquaEdu Workshop  
on Best Practices and  
Technologies in By-  
product Valorization  
26.09.2024**

**PRESENTED BY: ECE KENDIR CAKMAK, PHD**



Co-funded by  
the European Union



Sustainable Blue  
Economy Partnership

***Improved Valorization of  
Marine Sources and  
Processing Waste for  
Resource Efficient Blue  
Food/Feed and  
Environmental Sustainable  
Materials Development***

## **Our Aim**

SEAREFINERY aims to establish a novel bio-based blue food/feed and blue food packaging materials production platform by embracing marine-based secondary sources and wastes at transnational level.

FORMAS



Ministero delle Imprese  
e del Made in Italy



TÜBİTAK

The Research  
Council of Norway



# OUR TEAM



ITÜ



eman ta zabal zazu



Universidad  
del País Vasco

Euskal Herriko  
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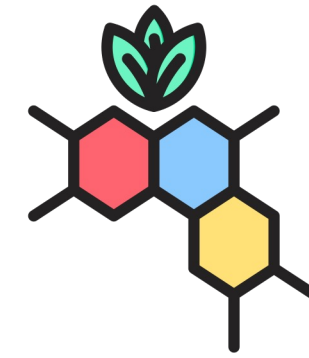
# HIGHLIGHTS



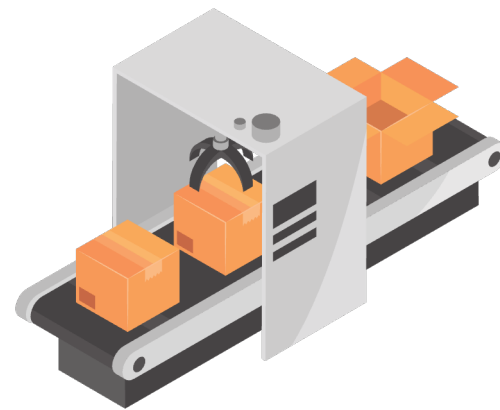
**5 SEAS**



**8 MARINE BASED  
SECONDARY  
SOURCES**



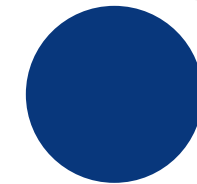
**11 VALUE  
ADDED  
COMPOUNDS**



**2  
PRODUCTION  
PATHWAYS**



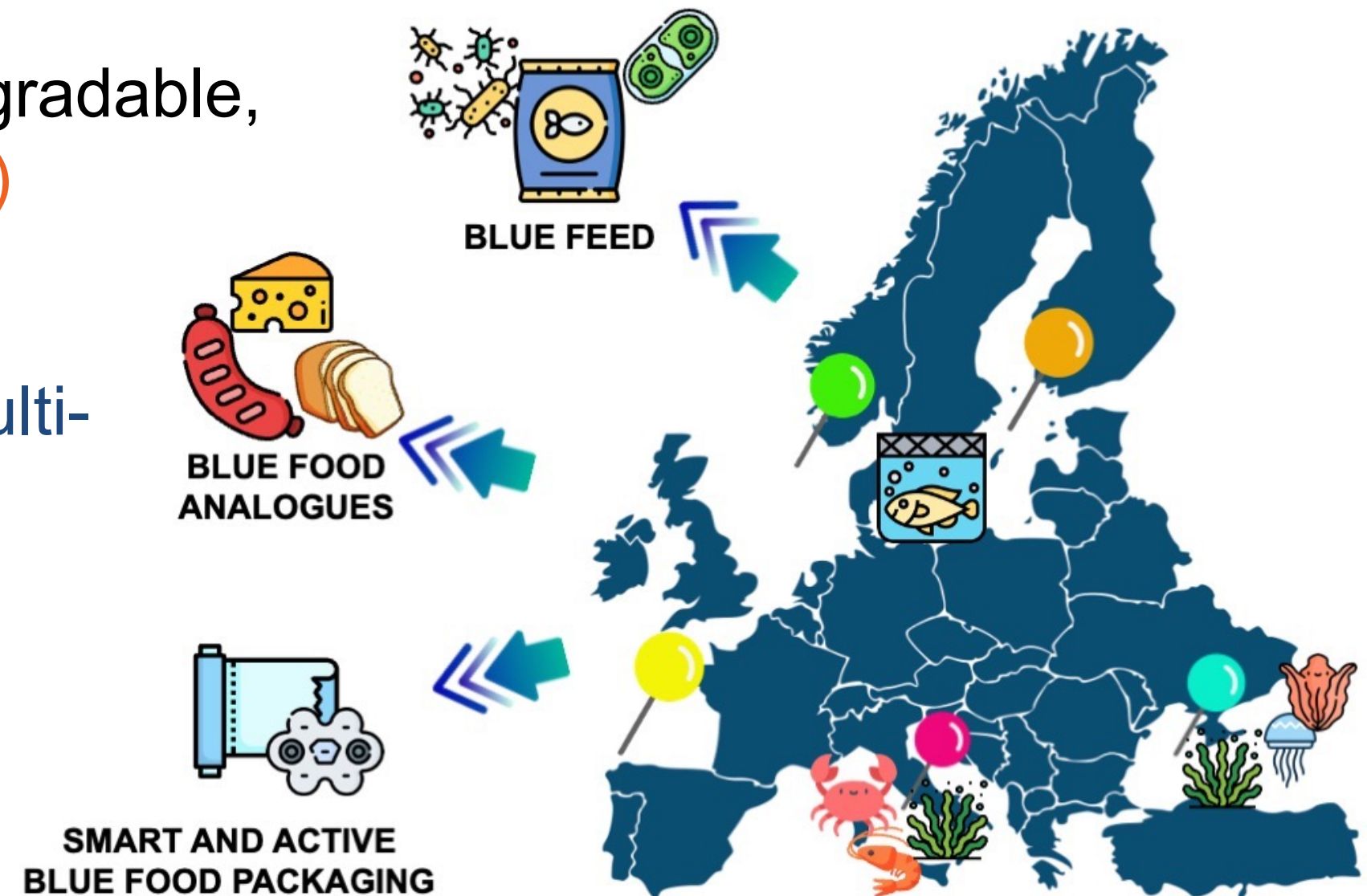
**8 END-  
PRODUCTS**





# OBJECTIVES

- To **extract marine-based materials**: alginate, chitosan, collagen, carrageenan, high-value biopolymers, proteins, lipids, bioactive compounds, and inorganics **(WP2)**
- To design and produce innovative, healthy and sustainable **blue foods** **(WP3)**
- To develop **fish feed** from waste streams of marine sources and aquaculture **(WP4)**
- To develop and to test high performance, biodegradable, smart and active food packaging material **(WP5)**
- To analyze **environmental impacts, real market opportunities** of the developed end-products- **Multi-Criteria Decision making** **(WP6)**

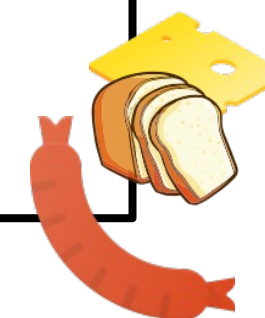




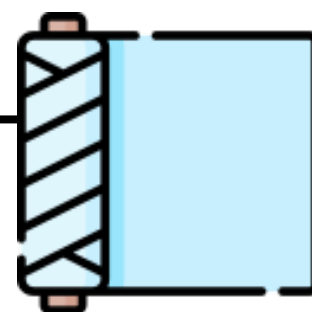


# EXPECTED ACHIEVEMENTS

The production of the new functional algae based meat, cheese and bread analogues



Active, biodegradable, edible and smart packaging material



Biosensor for food packaging for detection of microorganisms



Single Cell Protein (SCP) production process for fish feed

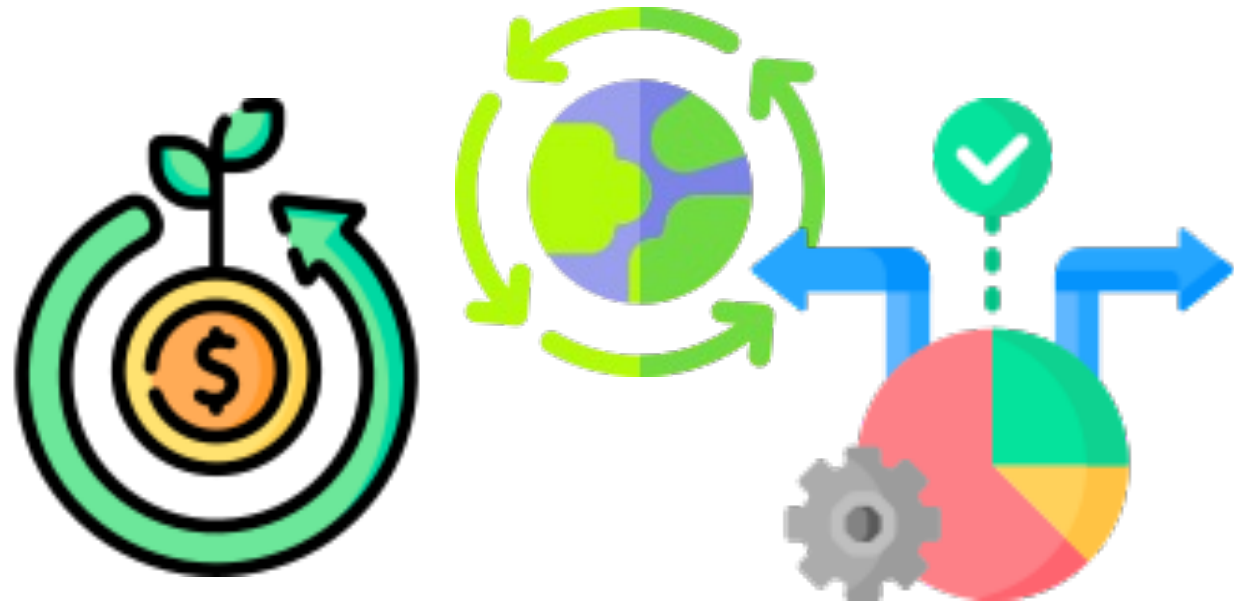


Integrated aquaculture wastewater treatment and a novel two-stage microalgae cultivation system for a circular fish food production





# CIRCULARITY ASSESSMENT



Market assessment and environmental assessment



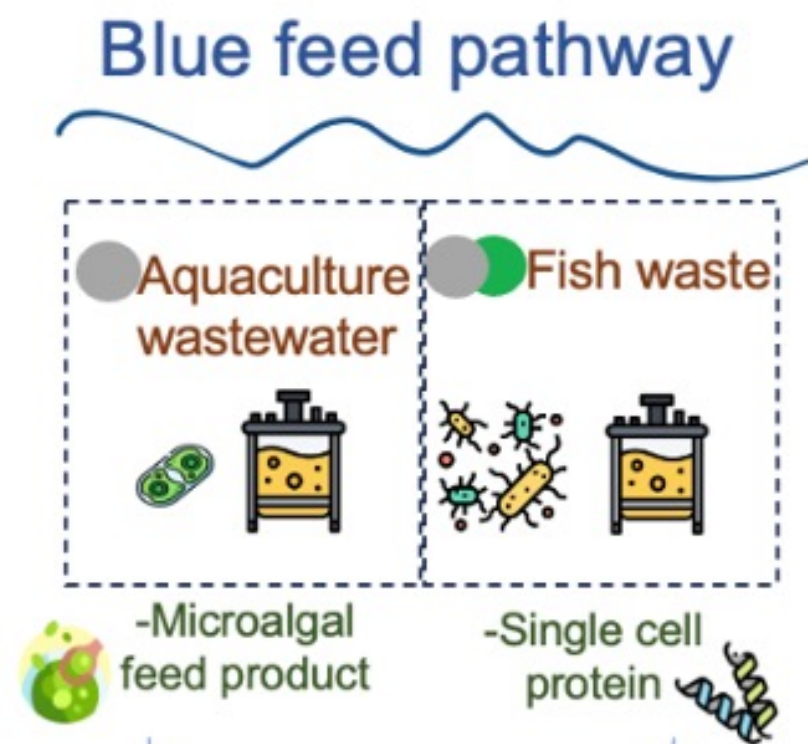
Stakeholder involvement



Promising products for sustainable blue economy

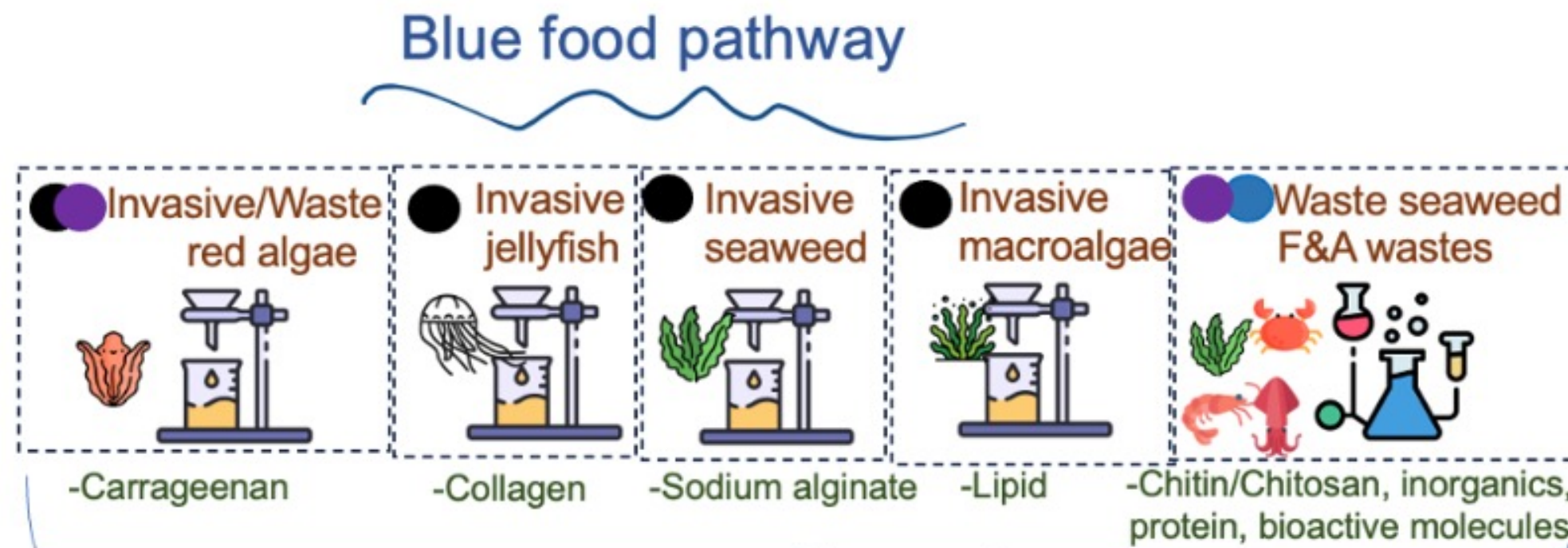


# SEAREFINERY PROCESS SCHEME



**BLUE FEED**

- Marine Source**
- The Black Sea
  - The Mediterrennean Sea
  - The Atlantic Ocean
  - The Baltic Sea
  - The North Sea



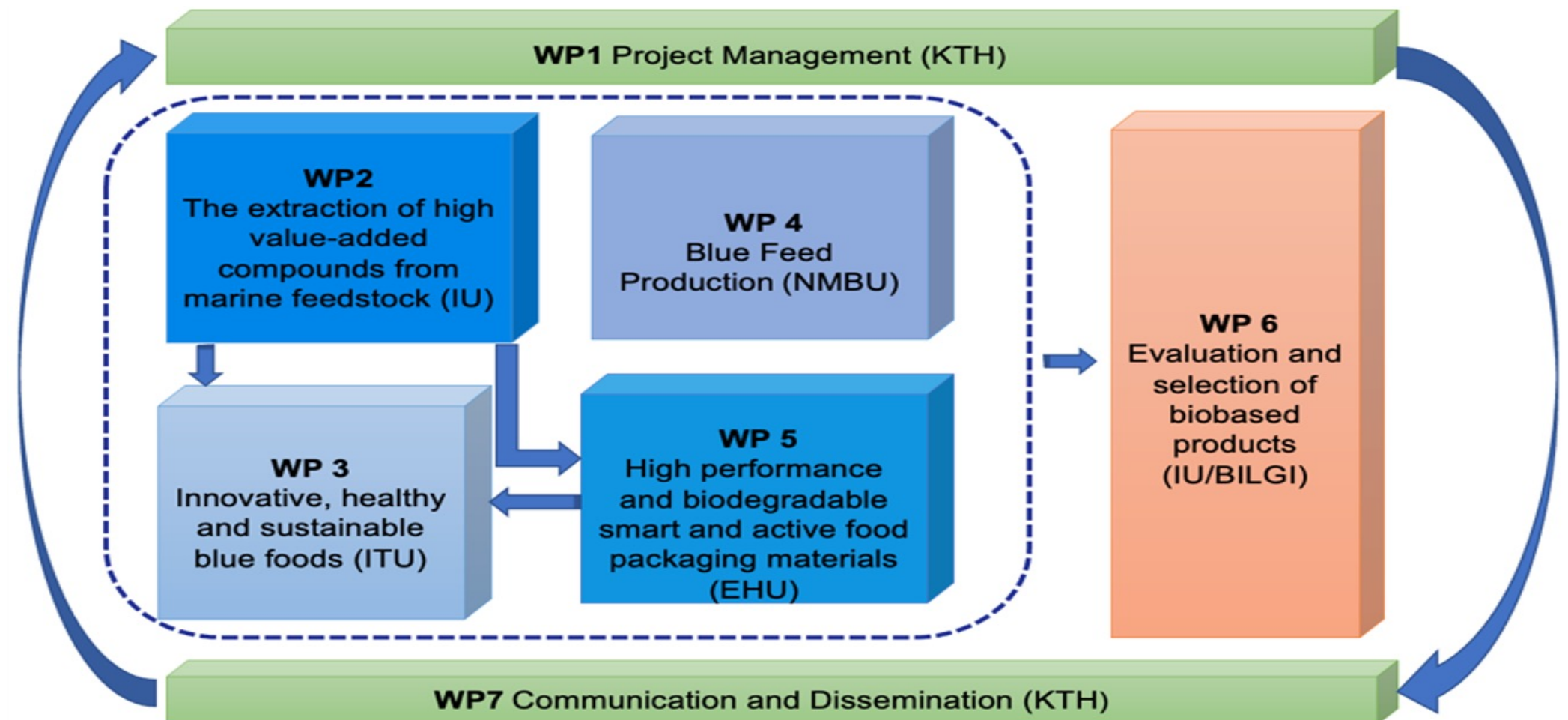
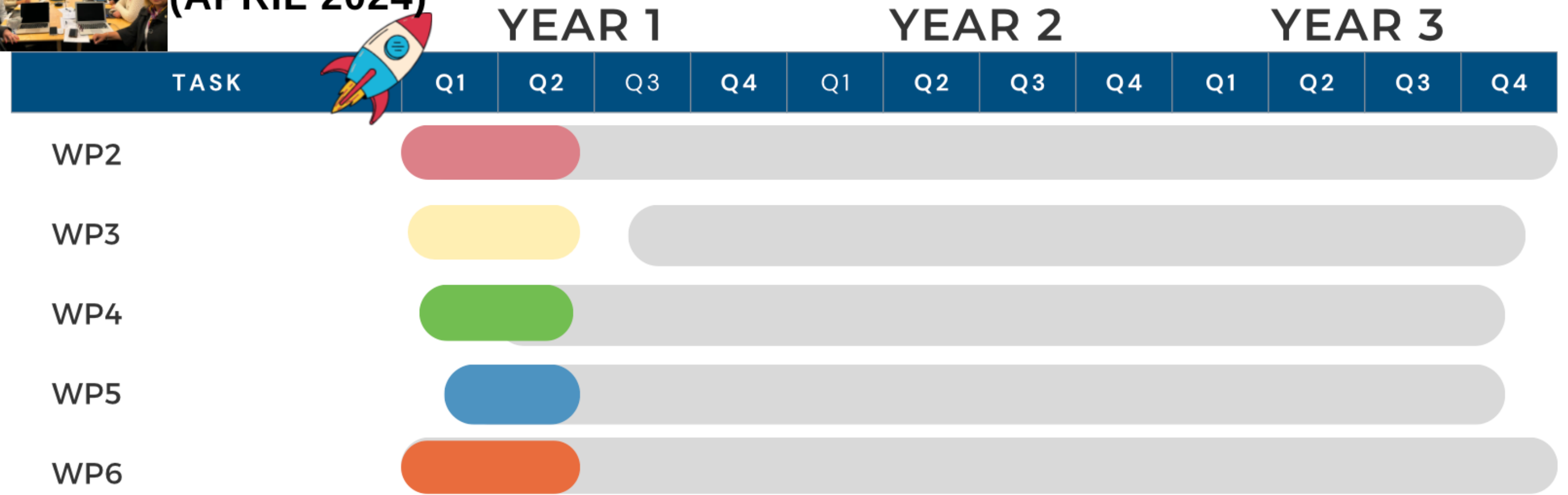
**BLUE FOOD ANALOGUE**

**SMART-ACTIVE PACKAGING**

# OVERVIEW OF THE WORK PACKAGES



**KICK-OFF  
MEETING  
(APRIL 2024)**





**MARINE BASED VALUE-  
ADDED COMPOUNDS**

**EXTRACTION OF VALUE ADDED  
COMPOUNDS**



**PROTEINS**



**LIPIDS**



**ALGINATE**



**CARRAGEENAN**



**COLLAGEN**



**CHITOSAN**



**HYDROXYAPATITE**



**CALCIUM  
CARBONATE**



**CARETENOIDS**



**POLYPHENOLS**



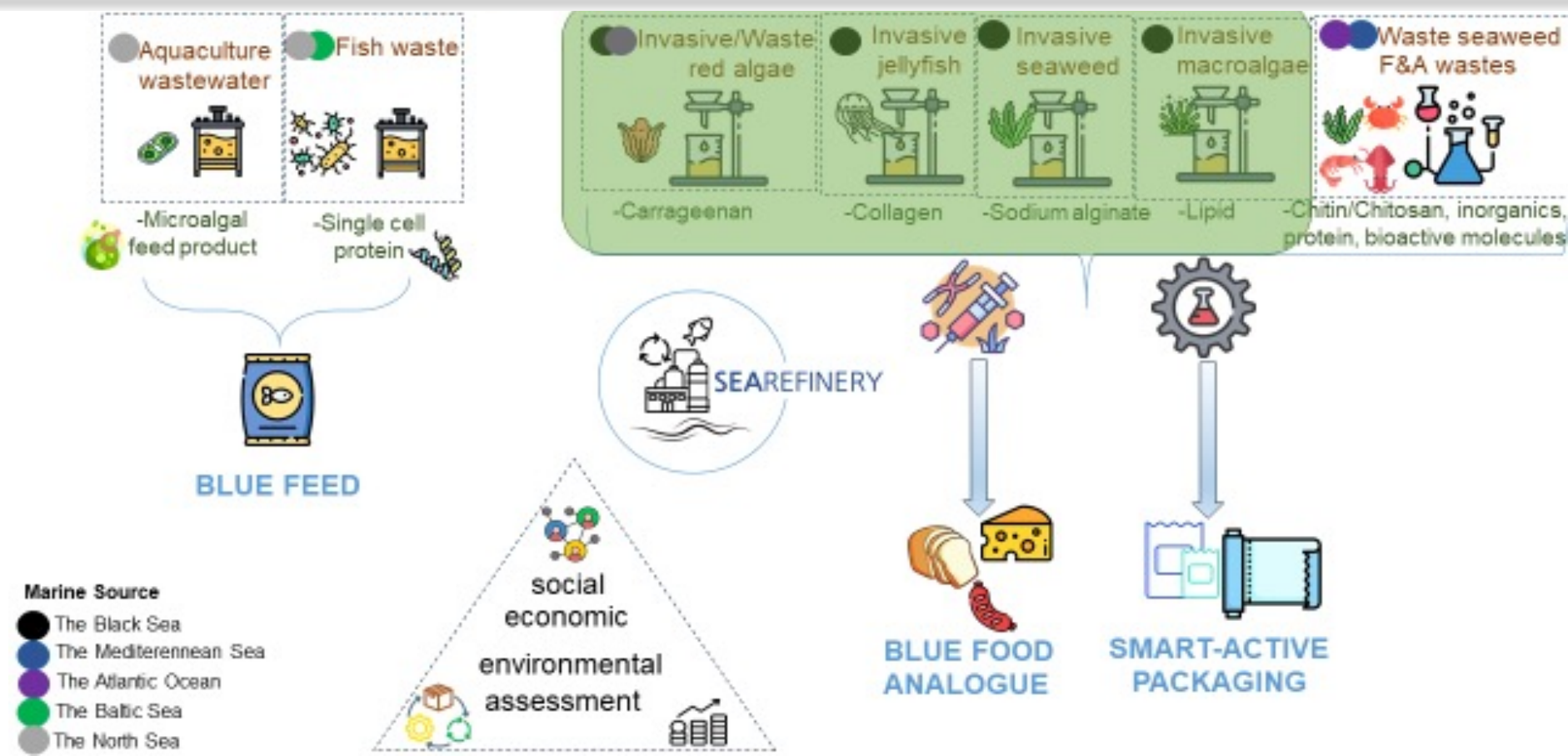
**BIOACTIVE  
PEPTIDES**

# WP 2- THE EXTRACTION OF VALUE-ADDED COMPOUNDS

- **Overall Objective:** To obtain high-value added compounds from invasive species and marine-based by products with eco-friendly methods products for considered marine areas.

## BBP1. High value-added compounds:

- Biopolymers (protein, lipids, alginate, chitosan, collagen, carrageenan) (>85% extraction efficiency)
- Inorganics (calcium carbonate from seashells, hydroxyapatite from fish bone and fish scale) (>80% extraction efficiency)
- Bioactive molecules such as carotenoids (fucoxanthins), polyphenols (phlorotannins) from seaweed and bioactive peptides from fish waste



Italian National  
Research Council



# WP 2- Biopolymers extraction



Collection of invasive species (*algae-Ulva lactuca*, *jellyfish*) from the Black Sea



**Step 1: Drying (solar energy/a rotary tray dryer)**

**Step 2: Extraction**

**Carrageenan :** Solvent-solvent extraction process from red algae.

**Collagen extraction:** Acetic acid extraction followed by dialysis for purification

**Sodium alginate:** Ethanol pre-treatment

**Polysaccharides:** Ultrasound-assisted extraction

**Lipids:** Soxhlet extraction from invasive macroalgae

# WP 2- Bioactive molecules extraction

Collection of seaweed and fish waste (anchovies, tuna, seabass, shrimps) from the Mediterranean Sea and the Atlantic Ocean

**Step 1: Drying and milling**

**Step 2: Extraction**

**Bioactive peptides:** An enzymatic protein hydrolysis (trypsin, alcalase and substilisin)

**Carotenoid and polyphenol pigments (fucoxanthin, phlorotannin):** Microwave (MW) and ultrasound (US) assisted hydroalcoholic/acetone extraction.

**Hydroxyapatite and calcium carbonate:** Calcination, alkaline and enzymatic hydrolysis.





# FOOD ANALOGUES



**FORMULATION  
AND PRODUCTION  
OF MEAT  
ANALOGUE**



**FORMULATION AND  
PRODUCTION  
OF CHEESE  
ANALOGUE**



**FORMULATION AND  
PRODUCTION  
OF FUNCTIONAL  
BREAD**



# WP3: INNOVATIVE, HEALTHY AND SUSTAINABLE BLUE FOODS

itü



- **Overall objective:** To develop novel functional marine-based food products

## **BBP2. Blue food products:**

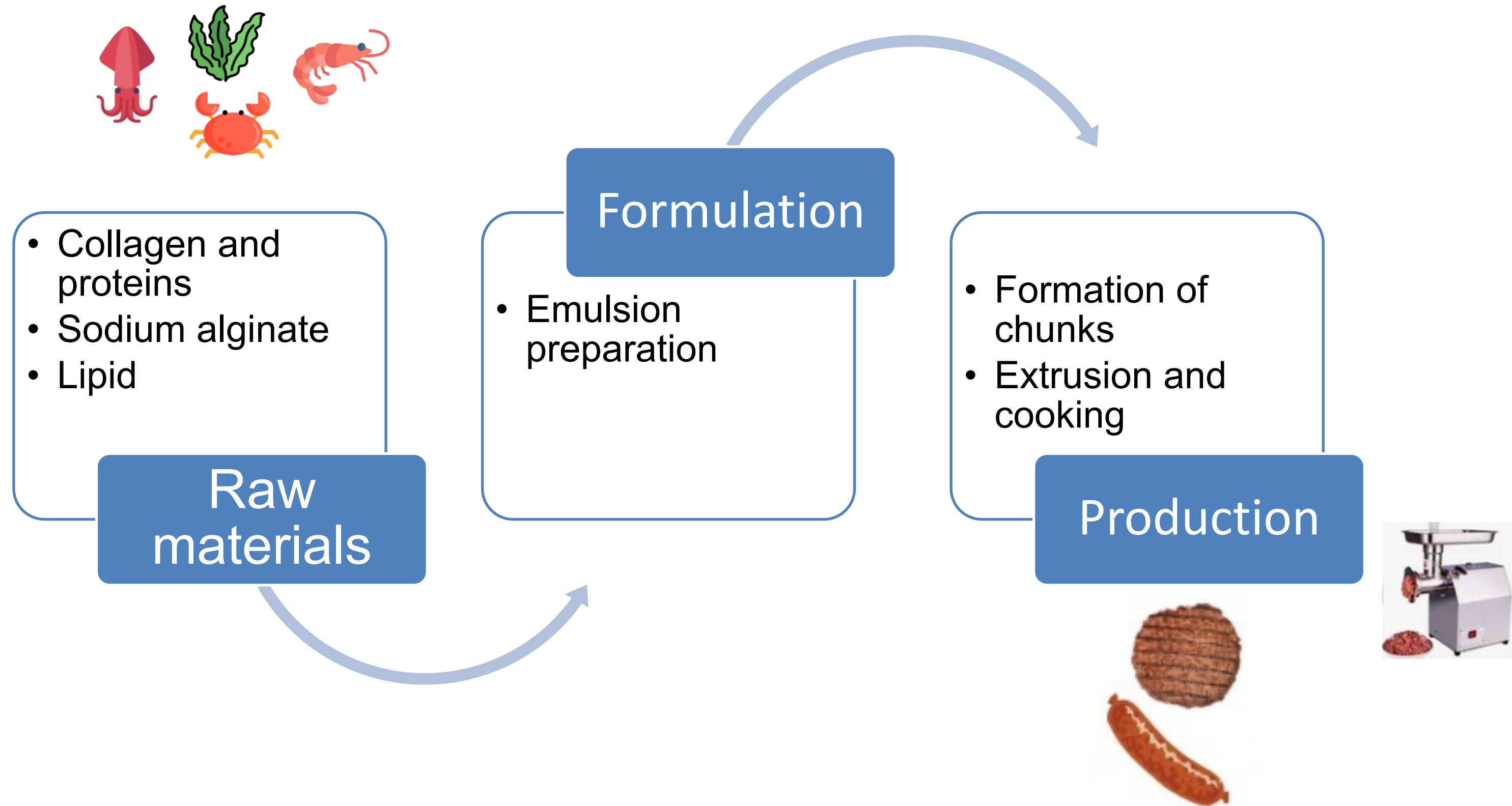
- Meat and cheese analog based on marine-based ingredients with “High protein (>20% of the energy value of the food)” / “High in omega-3 fatty acids (>80 mg of EPA and DHA per 100 g)” declarations on the product label.
- Functional bread with >50% protein by weight enriched with phenolics, inorganics, dried whole algae powder, essential amino acids and omega 3 fatty acids.

TRL levels  
From 2-3 to TRL 4

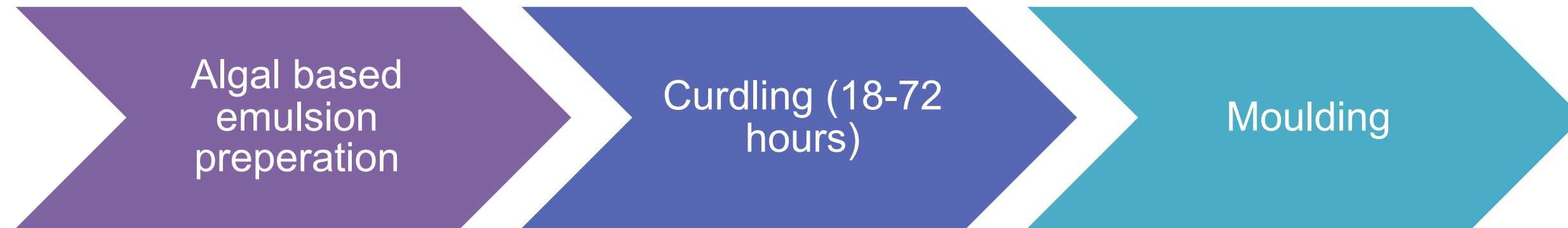




# Formulation and production of meat analogue



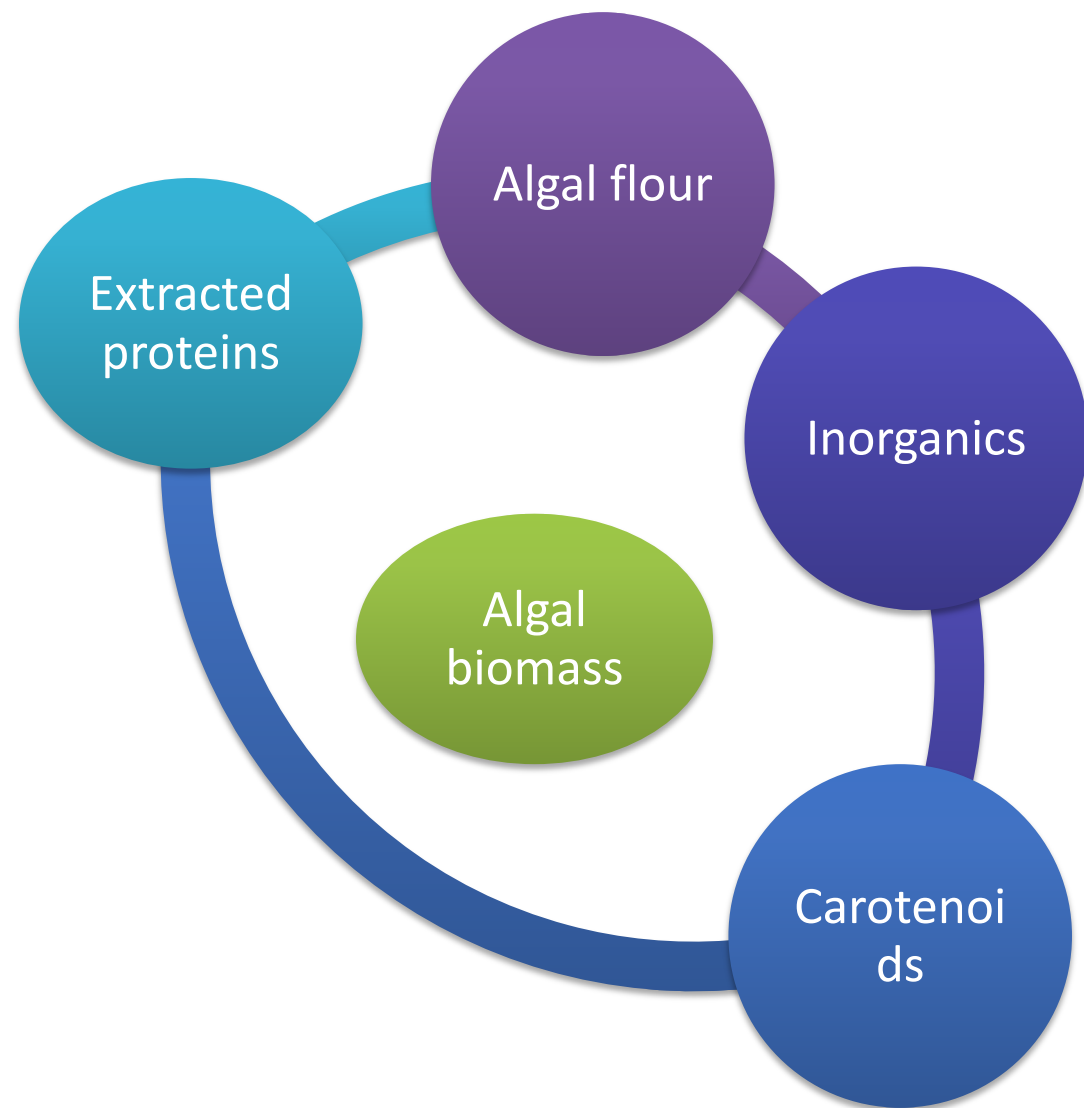
# Formulation and production of cheese analogue



Product 1: Emulsion preparation before heating



# Formulation and production of functional bread



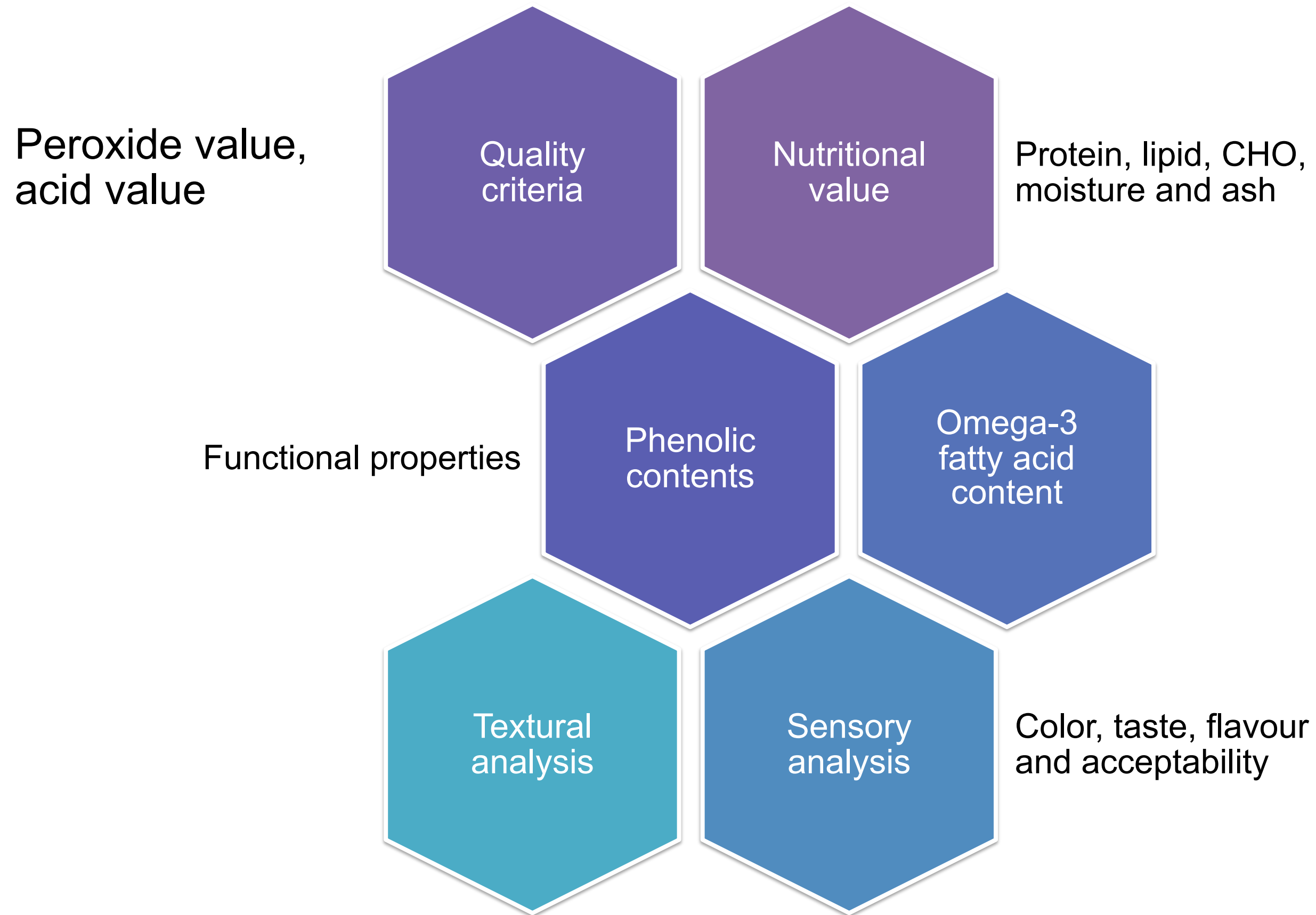
Mixing the ingredients



Dough  
↓  
Leavening  
↓  
Baking in the oven



# Characterization of blue foods





# WP5: HIGH PERFORMANCE AND BIODEGRADABLE SMART AND ACTIVE FOOD PACKAGING SOLUTIONS

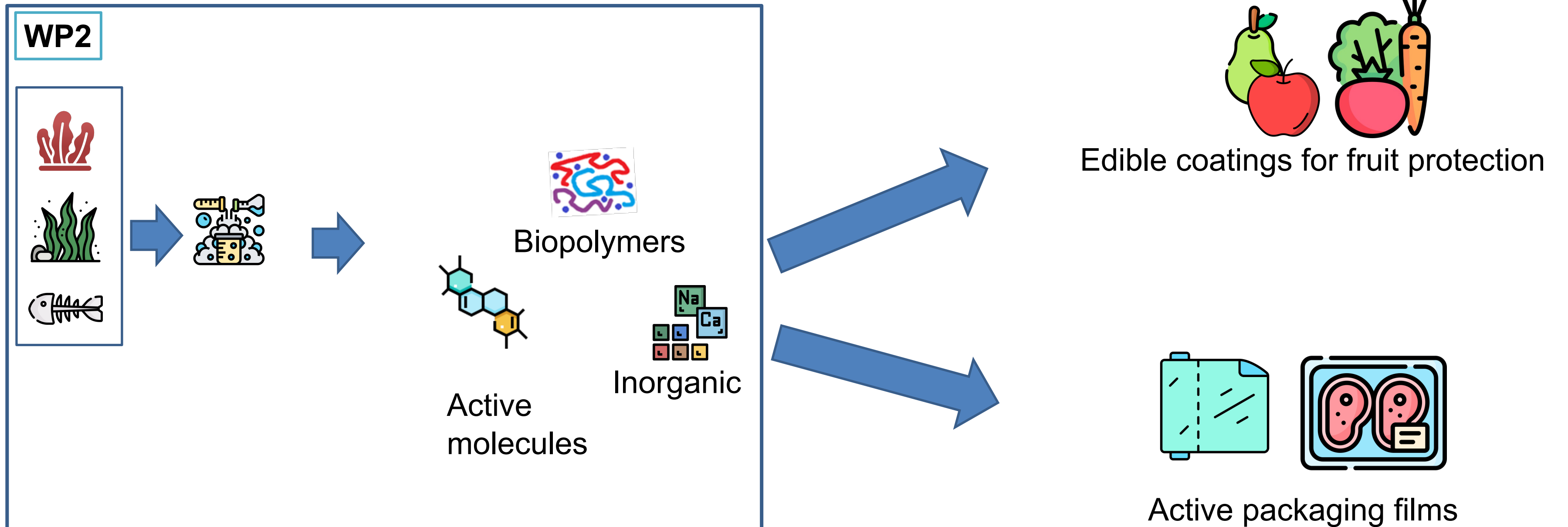
- **Overall objective:** To develop active and smart food packaging solutions from biopolymers and bioactive materials extracted (WP2) from the Black Sea, the Mediterranean Sea and the Atlantic Ocean marine resources.

## **BBP4. Smart and active food packaging materials:**

- Conversion of biopolymers and bioactive materials to 3 families (1 edible coating, 1 active film with antioxidant/antimicrobial capability, nanofiber) of food packaging products with high thermal stability (max. weight loss rate ~10.0%), high oxygen barrier ( $< 3 \text{ cc}\cdot\text{mil}\cdot\text{m}^{-2}\cdot\text{day}^{-1} \text{ atm}$ ), mechanical strength and excellent antimicrobial activity ( $> 4 \text{ log CFU/mL}$  decrease).
- Biosensor will be tested in the detection range of  $10^{-1}$  -  $10^5$  CFU/mL. The target for the detection limit expected to be 30-50 CFU/mL.

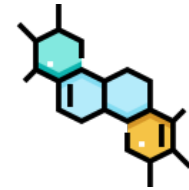


# Active Food Packaging Materials





# Active Food Packaging Materials



polyphenols and carotenoids

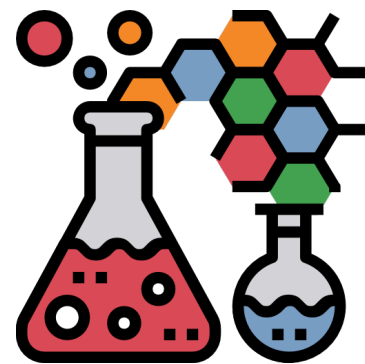
antioxidants and antimicrobial



Biopolymers

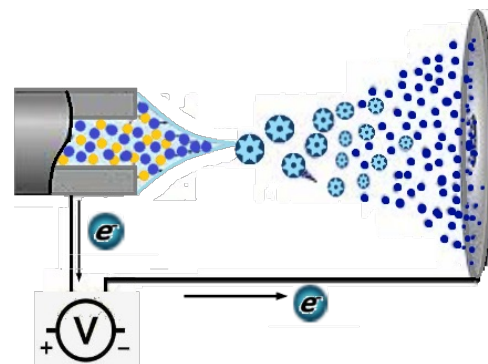
Biodegradable and edible

1



Formulations without and with nanocarriers

2

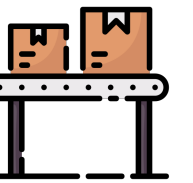


Electro sprayed nanocarriers

3

Fabrication of edible films

- Dipping
- Spraying

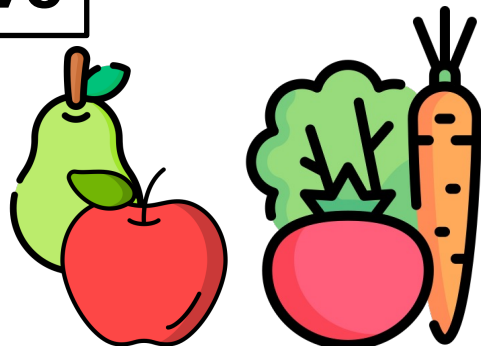


4

Characterization

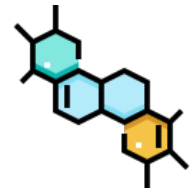
- Mechanical properties
- Structure
- Thermal properties
- Morphology
- Optical properties
- Gas barrier properties
- Biodegradability

Objective



Edible coatings for fruit protection

# Active Food Packaging Materials



polyphenols and carotenoids

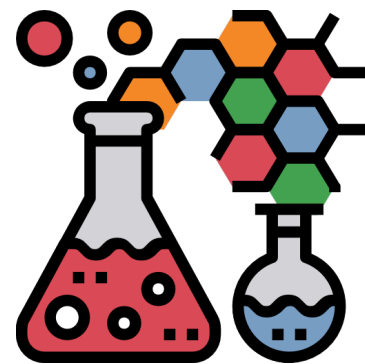
antioxidants and antimicrobial



Biopolymers

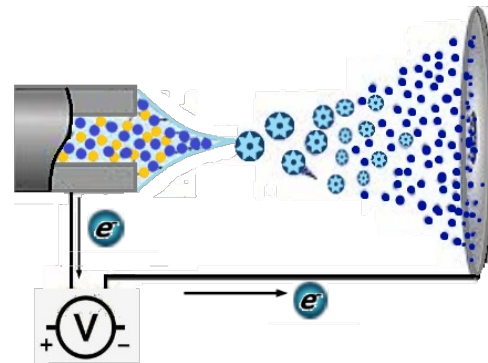
Biodegradable and edible

1



Formulations without and with nanocarriers

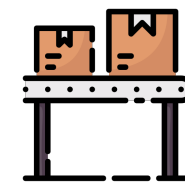
2



Electro sprayed nanocarriers

3

Fabrication of active packaging films



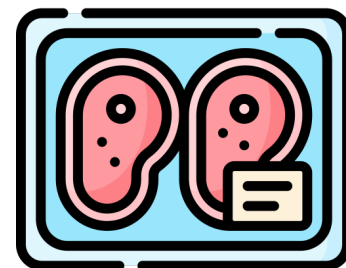
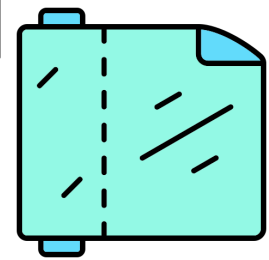
- Dr. Blade
- Casting
- Electrospinning

4

Characterization

- Mechanical properties
- Structure
- Thermal properties
- Morphology
- Optical properties
- Gas barrier properties
- Biodegradability

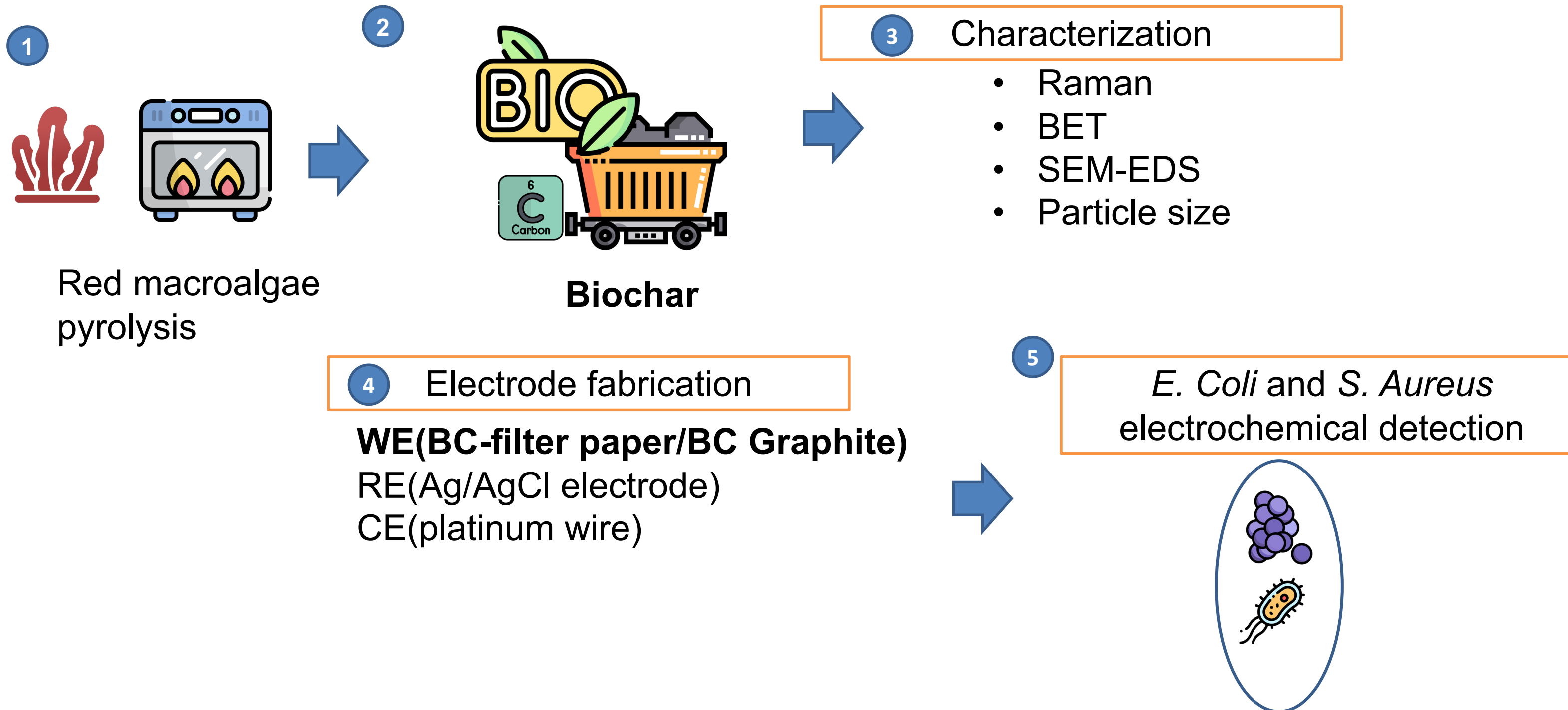
Objective



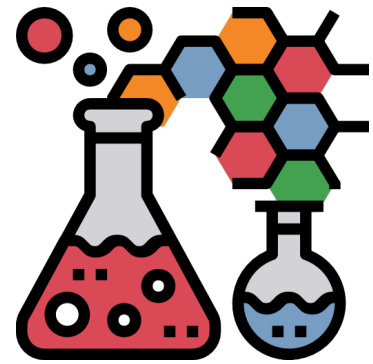
Active packaging films



# Development of Biosensor as a Smart Food Packaging Material



# Development of multifunctional food and feed packaging



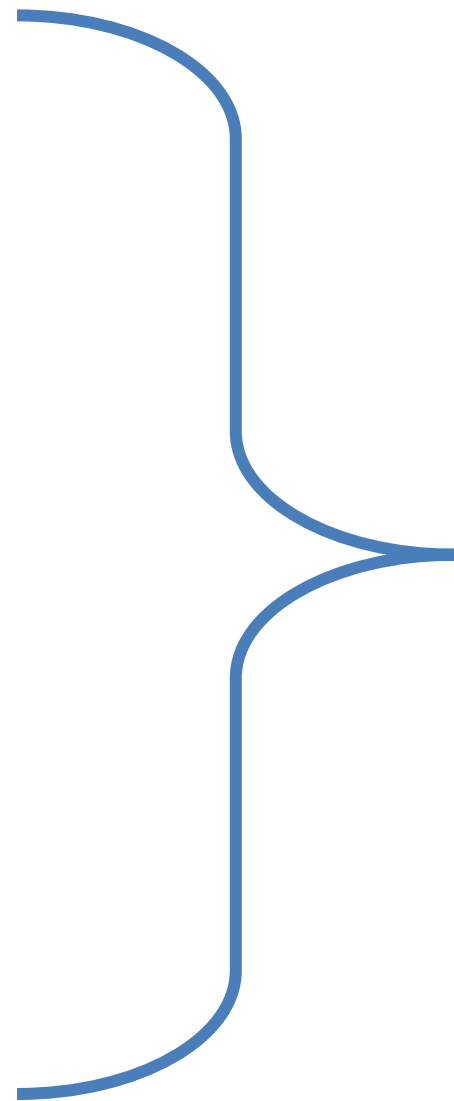
Active molecules  
and nanocarriers



Active films



Biosensor

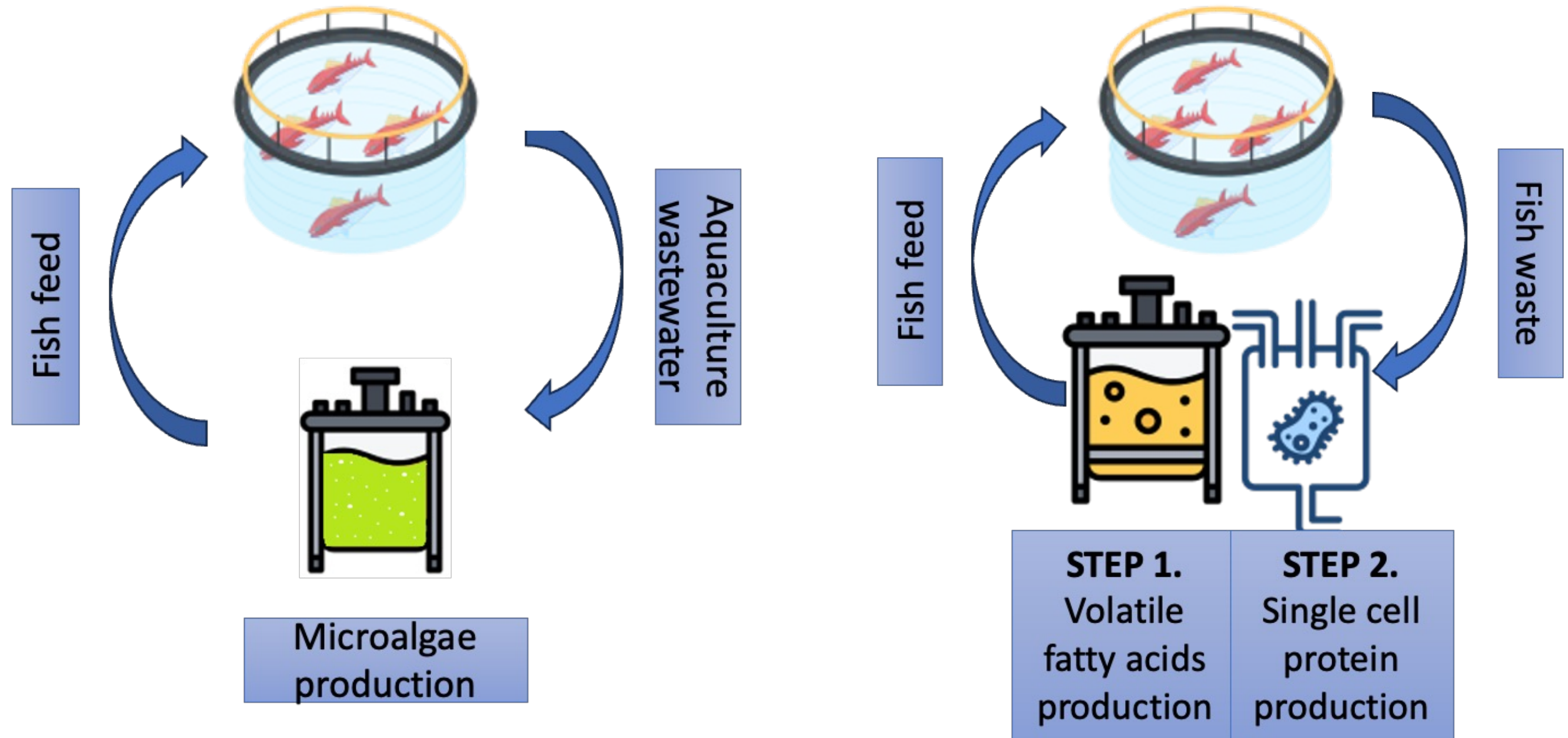


Smart and active packaging  
demonstrator



# BLUE FEED PATHWAY

## MICROALGAE & BACTERIAL PROTEIN FOR BLUE FEED APPLICATIONS



# WP4: BLUE FEED PRODUCTION



- **Overall objective:** To develop blue feed production strategies from aquaculture wastewater and fish waste using microalgae and bacteria



## **BBP3. Blue feed products:**

- Microalgae biomass ( $>50$  g/m<sup>2</sup>day dry mass) rich in both essential amino acids, oil and fatty acids as sources of high-quality feed for farmed fish.
- SCP production by fish waste/aquaculture derived volatile fatty acids (VFAs) with a conversion efficiency  $>65\%$  and a yield  $>0.3$  g cell dried weight/g VFA.

# Microalgae biomass production from aquaculture wastewater & fish waste

**Step 1:** Developing integrated aquaculture wastewater pretreatment system: **biofiltration**

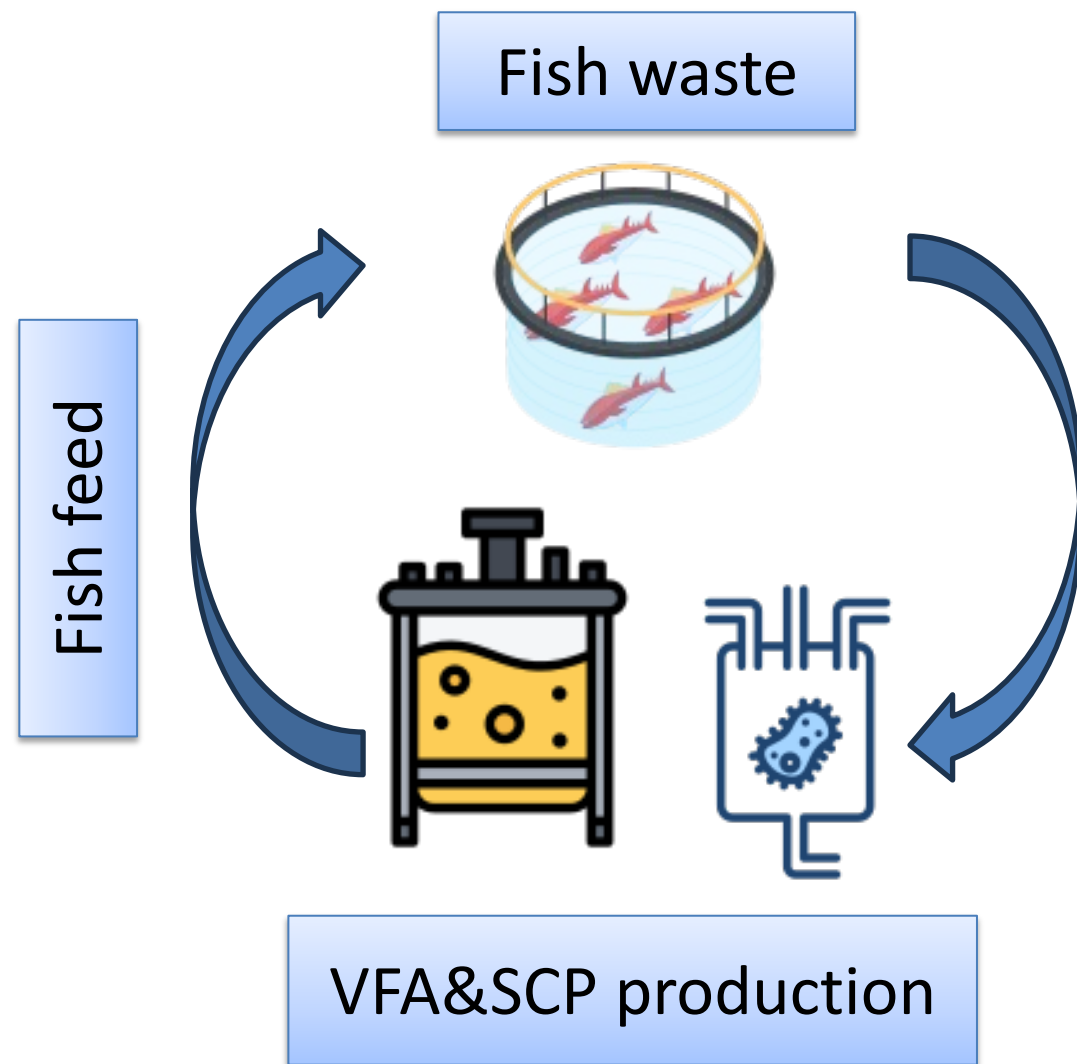
**Step 2:** Selection of suitable microalgal species: Cultivation of *Chlorella vulgaris*, *Dunaliella salina*, *Schizochytrium sp.*, *Nannochloropsis*, and *Haematococcus* for desired carbohydrate, protein and essential fatty acids)

**Step 3:** Testing multi-strain microalgae cultivation as mixed culture to formulate a balanced/complete feed product: **two- stage lab scale flat photobioreactor**





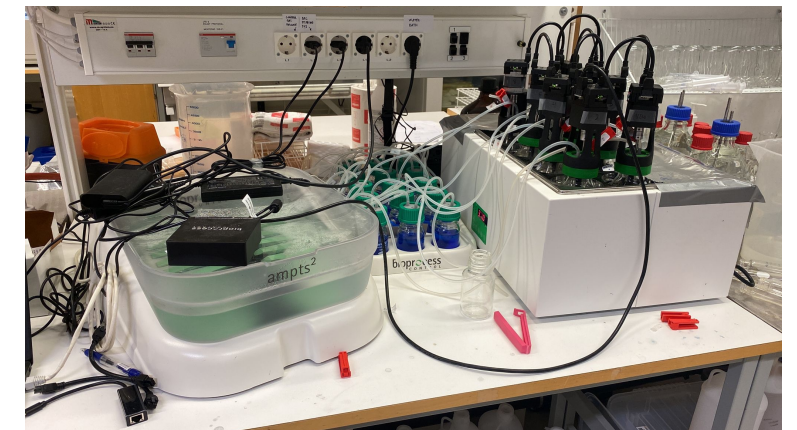
# Single Cell Protein (SCP) Production from Fish Waste



**Step 1: Fish Sludge Characterization**



**Step 2: Volatile Fatty Acid Production (Anaerobic fermentation)**



**Step 3: Single Cell Protein Production (Aerobic)**

*Cupriavidus necator*

*Thauera sp.*



**Step 4: Quality testing**

Crude protein, crude fat, minerals, crude fiber, carbohydrates, vitamins and amino acids.

# BIOPRODUCT ANALYSIS

## TECHNO-ECONOMIC ENVIRONMENTAL SOCIAL ASSESSMENT



# WP6: EVALUATION AND SELECTION OF BIOBASED PRODUCTS



- **Overall objective:** Selection of most promising **SEAREFINERY** algae-based products for considered marine areas.



**Step 1:** Environmental performance of SEAREFINERY products;

**Step 2:** Market potential and consumer acceptance of SEAREFINERY products

**Step 3:** Selected products with the most promising features in the different targeted marine areas.



# Market Assessment of the SEAREFINERY products

- A **market analysis** and an **economic assessment** of potential SEAREFINERY marine-derived products to be exploited at EU level. The study will include a quantitative analysis of the current state of the EU market and will evaluate present and expected market trends, including the potential geographic and economic dimensions of the markets for each product.
- **The pre-selection of 3 products**, each one from all product categories (i.e. packaging, food, feed etc) will be assessed at a workshop in April, 2024 with the attendance of *at least one representative from each WP, the Stakeholder Advisory Board and the Scientific Committee.*



# Environmental Assessment

- Environmental assessment of pre-selected products will be evaluated using LCA methodology.
- Life Cycle Inventories (LCI) of selected products: In contact with WPs 2-5
- Laboratory-scale LCA results will be upscaled to full scale by using ex-ante (or prospective) LCA techniques to be evaluated in comparison with the conventional products.



# Evaluation of consumers acceptance of the SEAREFINERY products

- A consumer survey, which will be aimed at investigating consumers' preferences, their purchasing behavior and their willingness to buy 'more sustainable' marine-based products (**3 selected products**).
- The survey will be done with the **Choice Experiment** model, that estimates the willingness to pay for a product based on its attributes, on a consumer sample of around 1,000 people across Europe.
- The social acceptance of the other products will be evaluated through targeted focus groups involving c.a. 10 consumers each carried out at local level with the aim to collect impressions, feedback and reactions

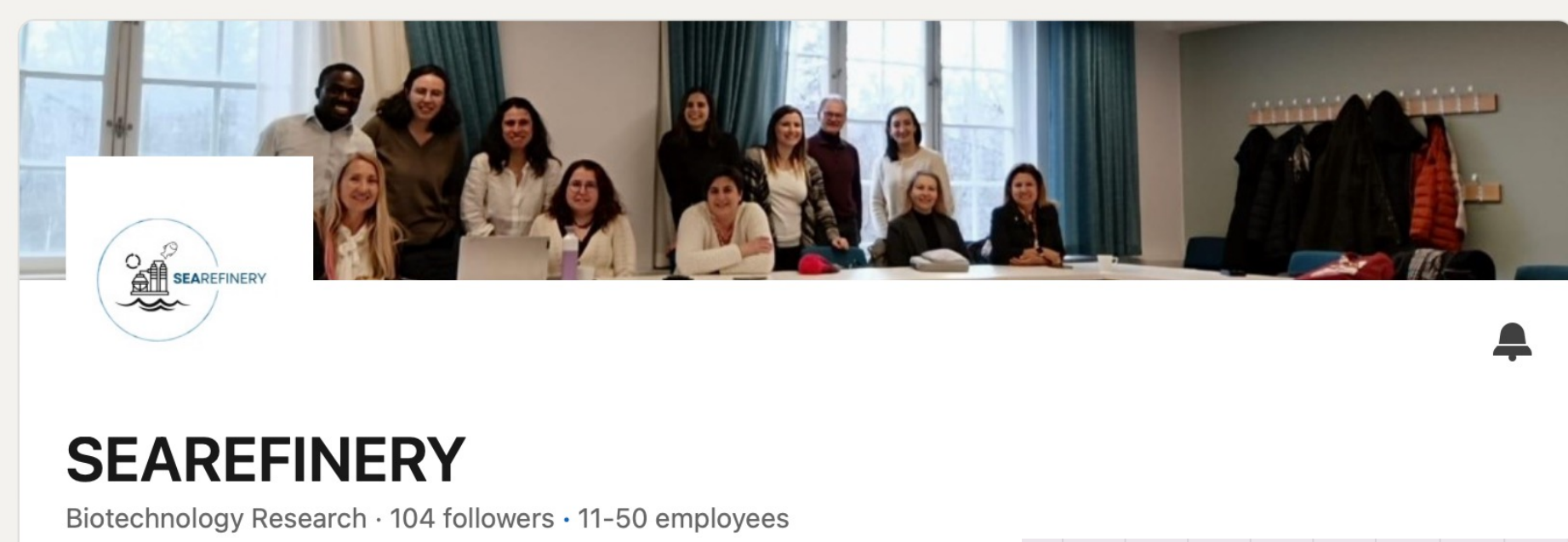




# Multi-Criteria Decision-Making Analysis for the ranking of SEAREFINERY products based on their innovation potential

- A decision-making tool will be developed to identify the products with the highest innovation potential.
- The tool will evaluate different aspects such as cost, price and quality of the processes and LCA results, and it will define the **most promising SEAREFINERY marine-based products**. by comparing their performance in different locations for further upscale.





# SEAREFINERY

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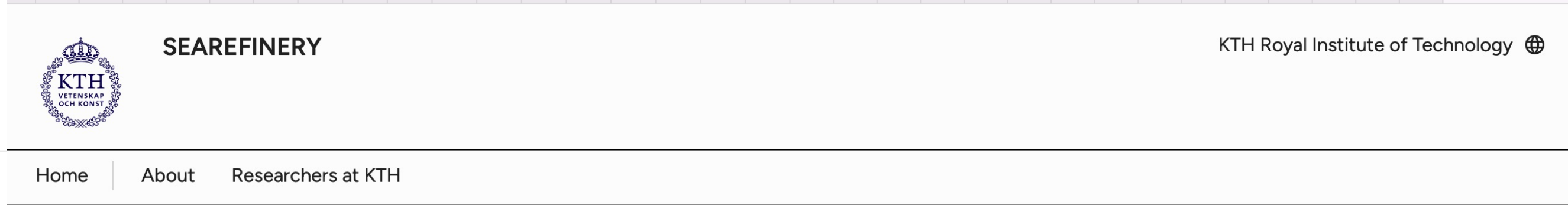
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### SEAREFINERY

Establishing a novel bio-based blue food/feed and blue food packaging materials production platform by embracing marine-based sources and wastes targeting five seas.

[Read more](#)

FaceTime



# Thank you! Contact us:



## Contact person

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