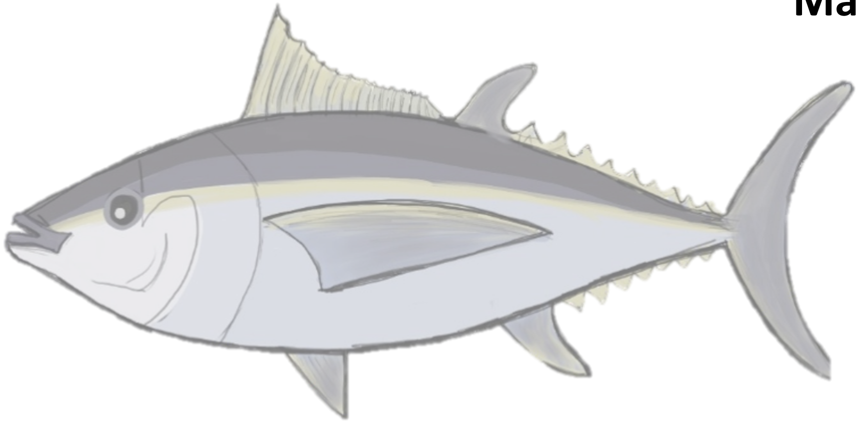
Valorization of fish processing waste through enzymatic extraction: a short review

10th International Conference on Sustainable Solid Waste Management Chania, Greece, 21 - 24 JUNE 2023



Dott. Silvia Fraterrigo Garofalo

Prof. Tonia Tommasi

Prof. Debora Fino

Food

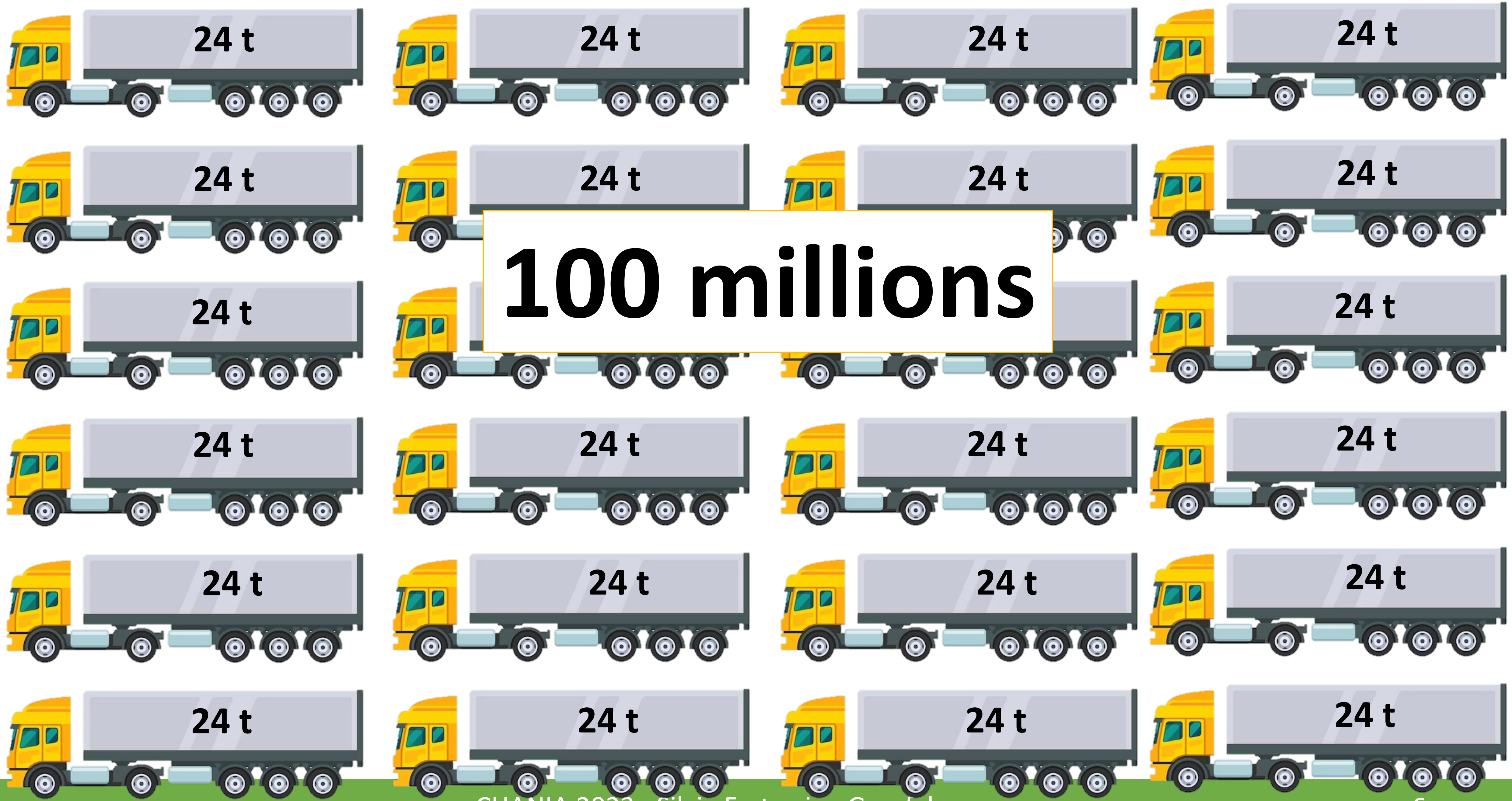
«We are what we eat...»

Food wastes

«We are what we ~~eat~~ waste...»

Food wastes

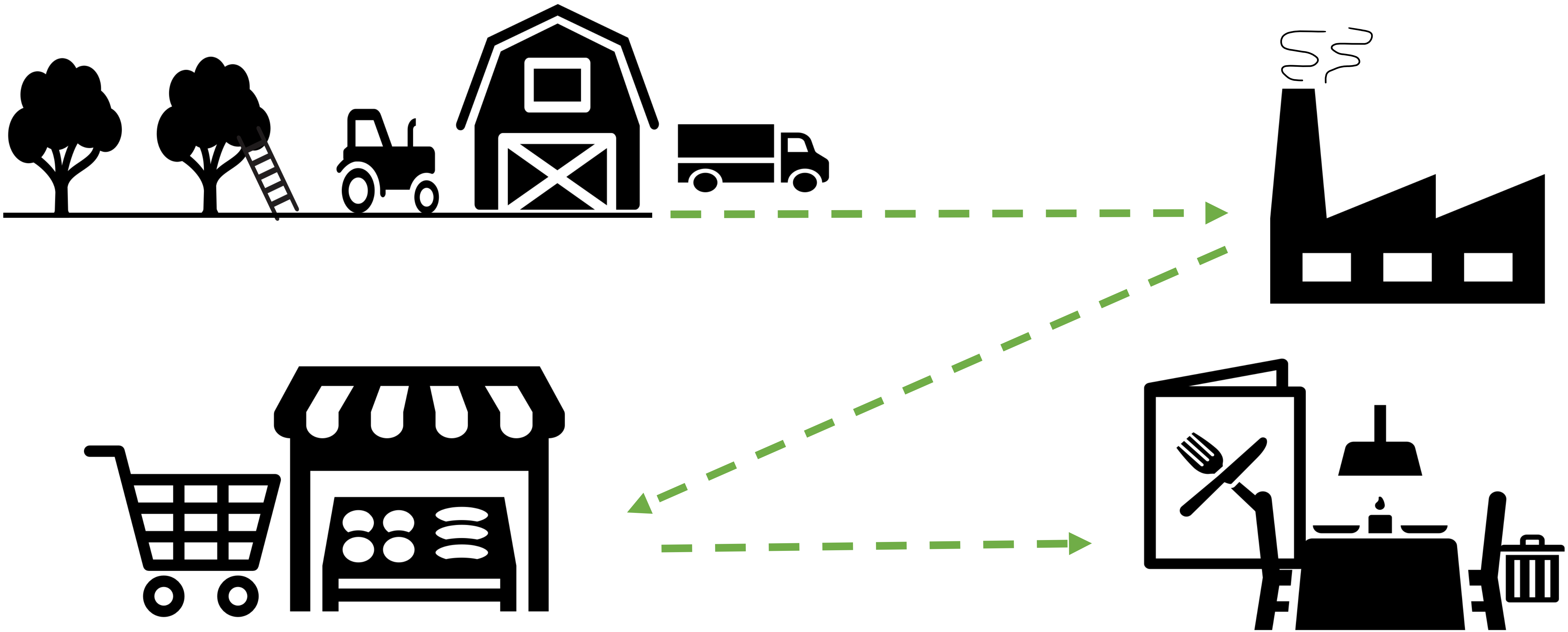
1/3



100 millions

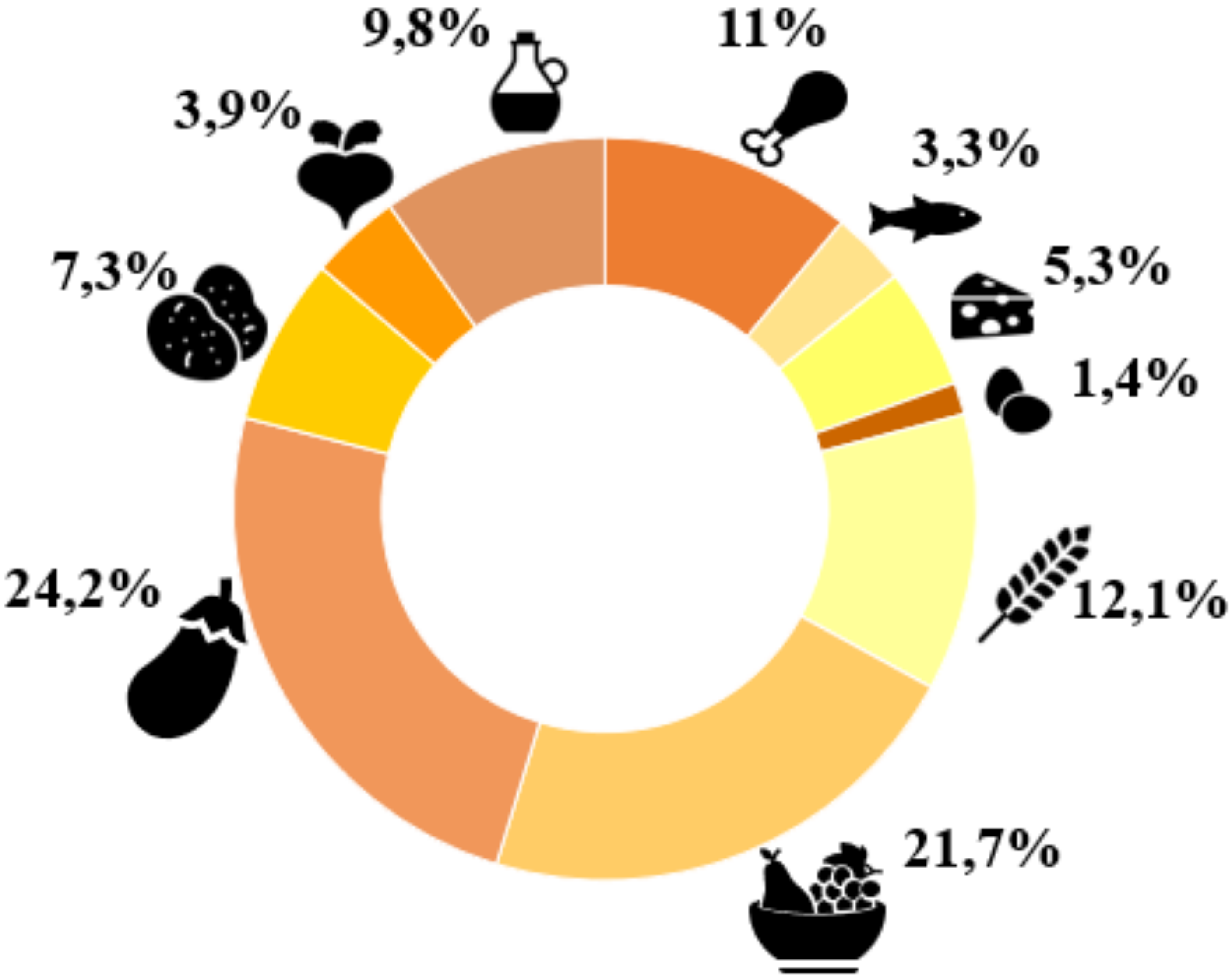

x4

Food wastes



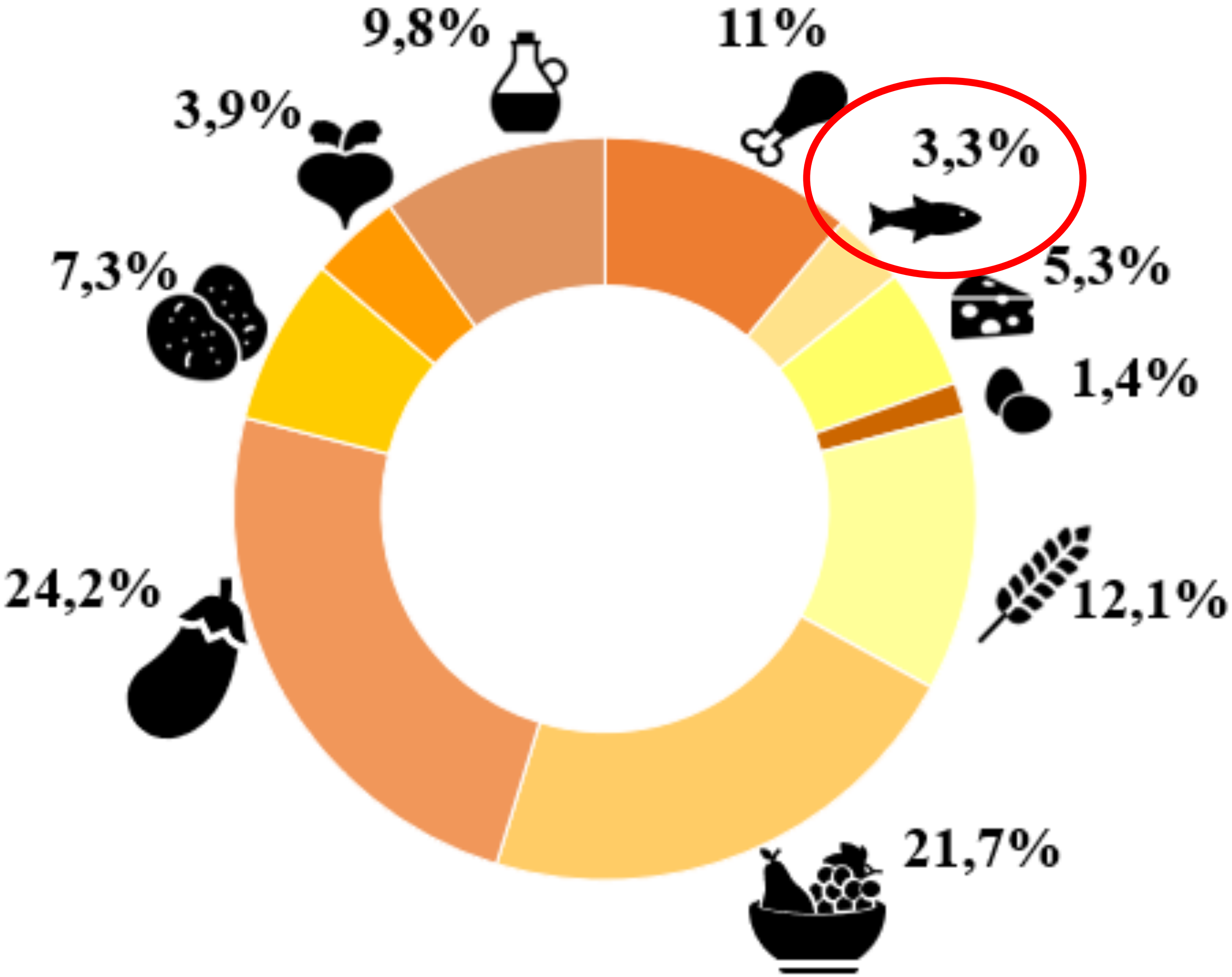
FLW Standard (2016) Food Loss and Waste Accounting and Reporting Standard. FLW Protocol

Food wastes



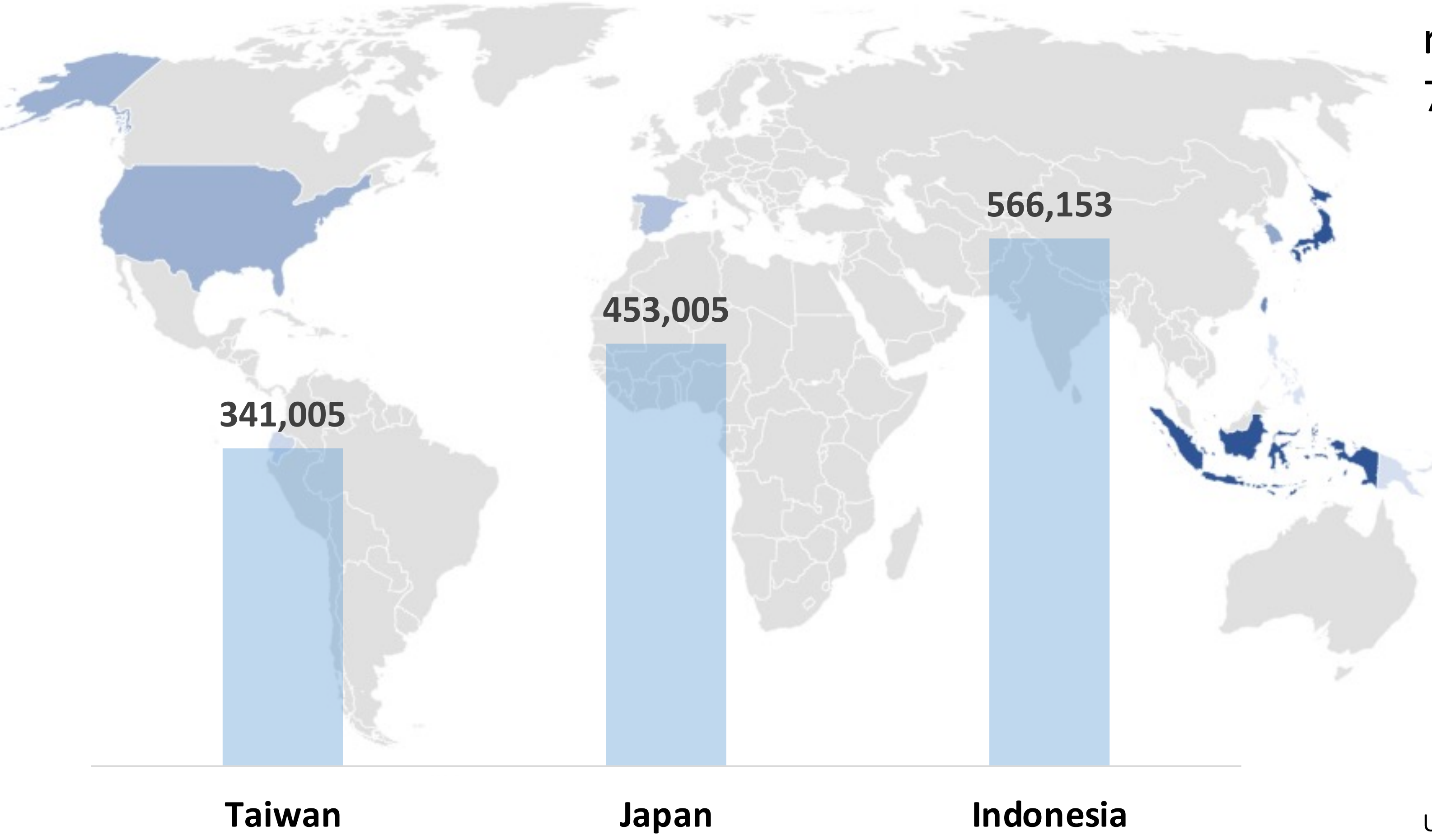
Corrado et al. (2017) J Clean Prod 140:847–859.
Caldeira et al (2019) Resour Conserv Recycl 149:479–488.

Food wastes



Canned tuna processing wastes

Tuna represents 20% of the value of all marine capture fisheries and over 8 % of all globally traded seafood.

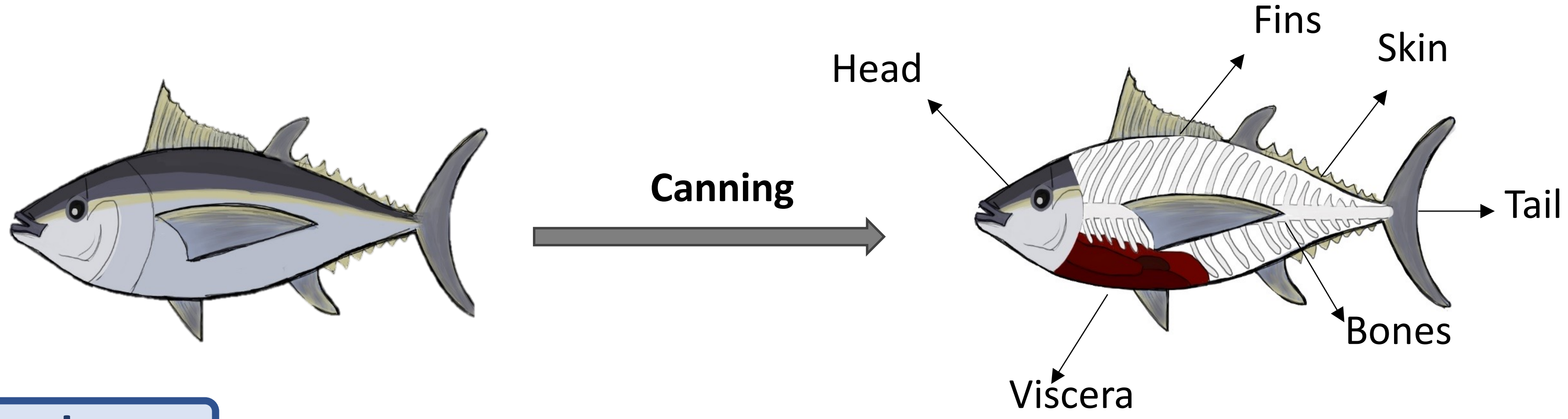


Catches of tuna and tuna-like species continued their year-on-year increase, reaching their highest levels in 2018 at over 7.9 million tonnes

Thailand, Ecuador, China, Indonesia, and were the largest exporters of canned and processed tuna (Italy 8th)

United Nation- World Tuna Day- https://www.un.org/en/observances/tuna-day
Overview, G., 2010. 4 4.1 Canned Tuna Processors 85–95.
FAO. 2020. The State of World Fisheries and Aquaculture 2020..

Canned tuna processing wastes



Main products

- **Fish protein hydrolysates (FPH)**
  antioxidant activity whit a high amount of antihypertensive, anticancer, anti-anemia peptides
- **Tuna oil**
  source of polyunsaturated fatty acids (PUFAs), especially omega-3 EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid)

By- products
50-70 %

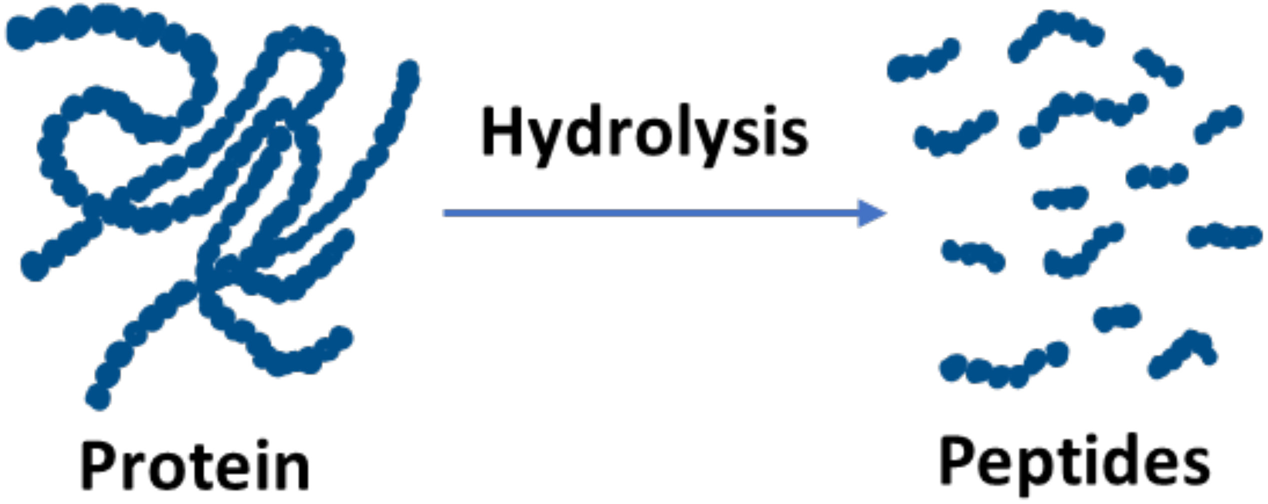
Still contain a high portion of valuable protein, lipid and nutritional components

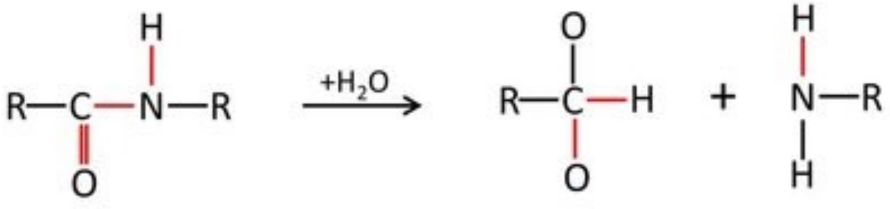
Herpandi et al. (2011). Compr Rev Food Sci Food Saf 10:195–207
Araujo et al. (2021) Waste and Biomass Valorization 12:847–855
Bergé et al. (2014) Report number: Policy Brief 21/2014. Affil. Secr. Pacific Community

Canned tuna processing wastes

• *Enzymatic extraction*

Enzymatic hydrolysis is an ideal method to recover **protein and lipids** from fish by-products/wastes



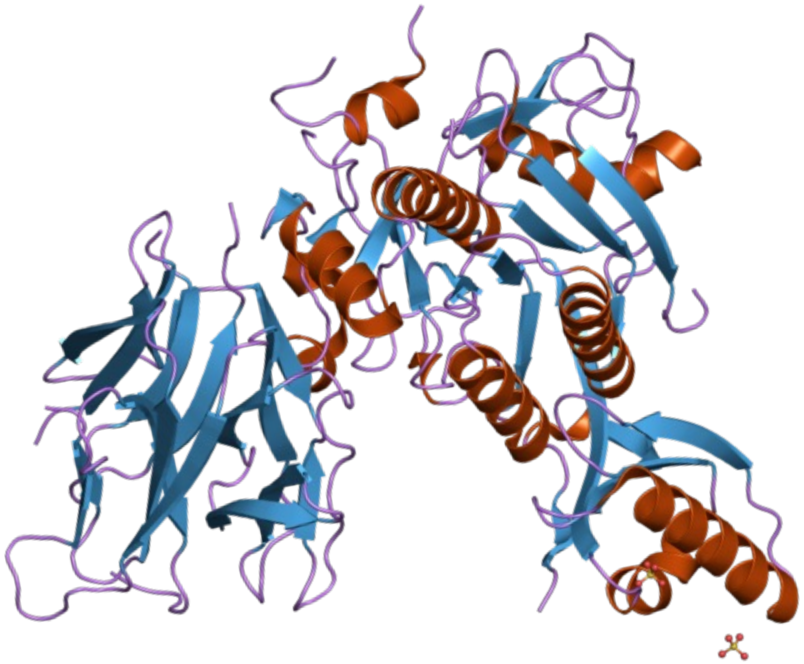


Hathwar et al. (2011) Appl. Biochem. Biotechnol. 164, 115–124.
Tacias-Pascacio et al. (2020) Int. J. Biol. Macromol. 165, 2143–2196.
Mensiena B. G. Kiewiet et al. (2018) Nutrients, 10, 904

Canned tuna processing wastes

- ***Enzymatic extraction***

Enzymatic hydrolysis is an ideal method to recover **<u>protein and lipids</u>** from fish by-products/wastes



One of the most used enzymes in the production of bioactive peptides and oil is **<u>Alcalase</u>**

- Alkaline proteases
- Obtained from *Bacillus subtilis*
- Optimum temperature **55°C**

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Valorization of tuna viscera

- ***Enzymatic extraction***

Deboning

Blending

Proteins %	17,70	± 0,20
Lipids %	2,58	± 0,08
Carbohydrates %	NR	
Humidity %	77,5	± 0,1
Hush %	2,22	± 0,1

Fraterrigo Garofalo et al. (2023) Food Bioprod. Process. 137, 155–167 (2023).

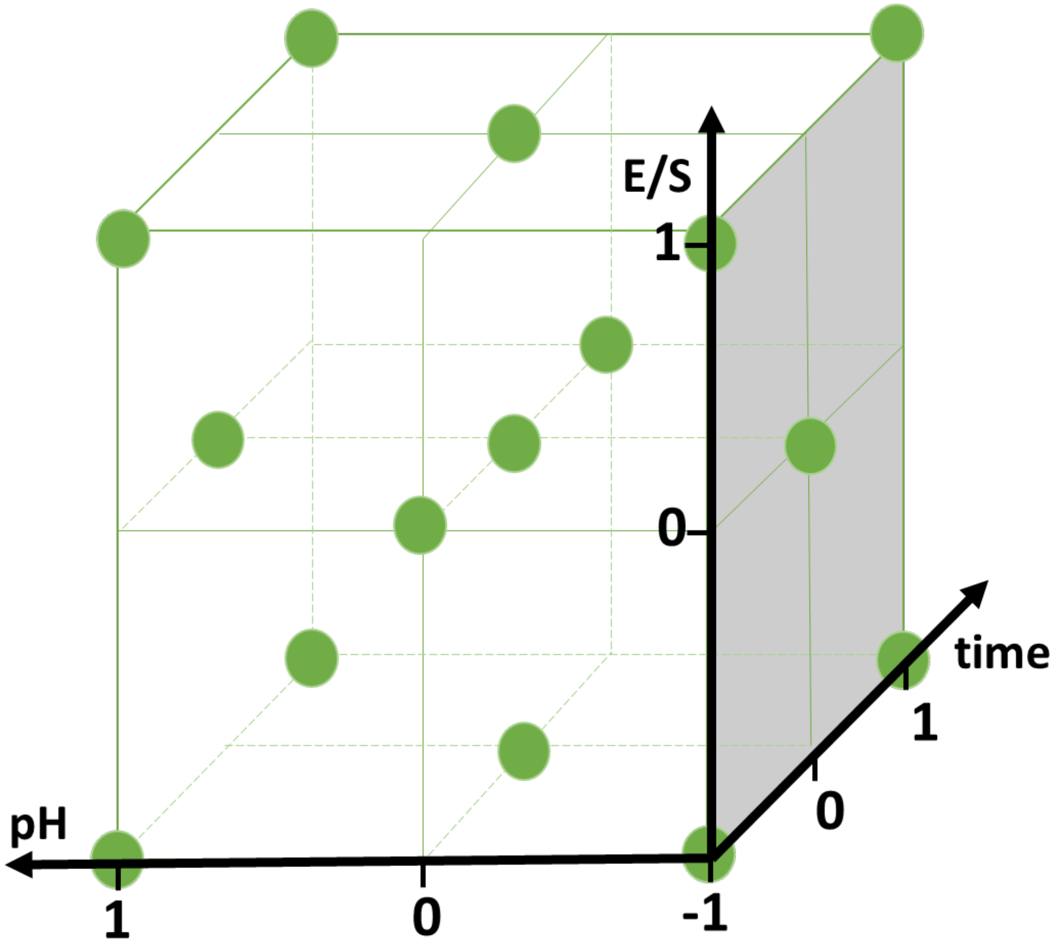
Valorization of tuna viscera

- *Enzymatic extraction*

DoE (MODDE 7 and CAT)

Central Composite Face Centered

Factors: E/S (%), t (min), pH
Levels: E/S (0,1-0,55-1 %)
t (30-75-120 min)
pH (6,5-7,5-8,5)



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Valorization of tuna viscera

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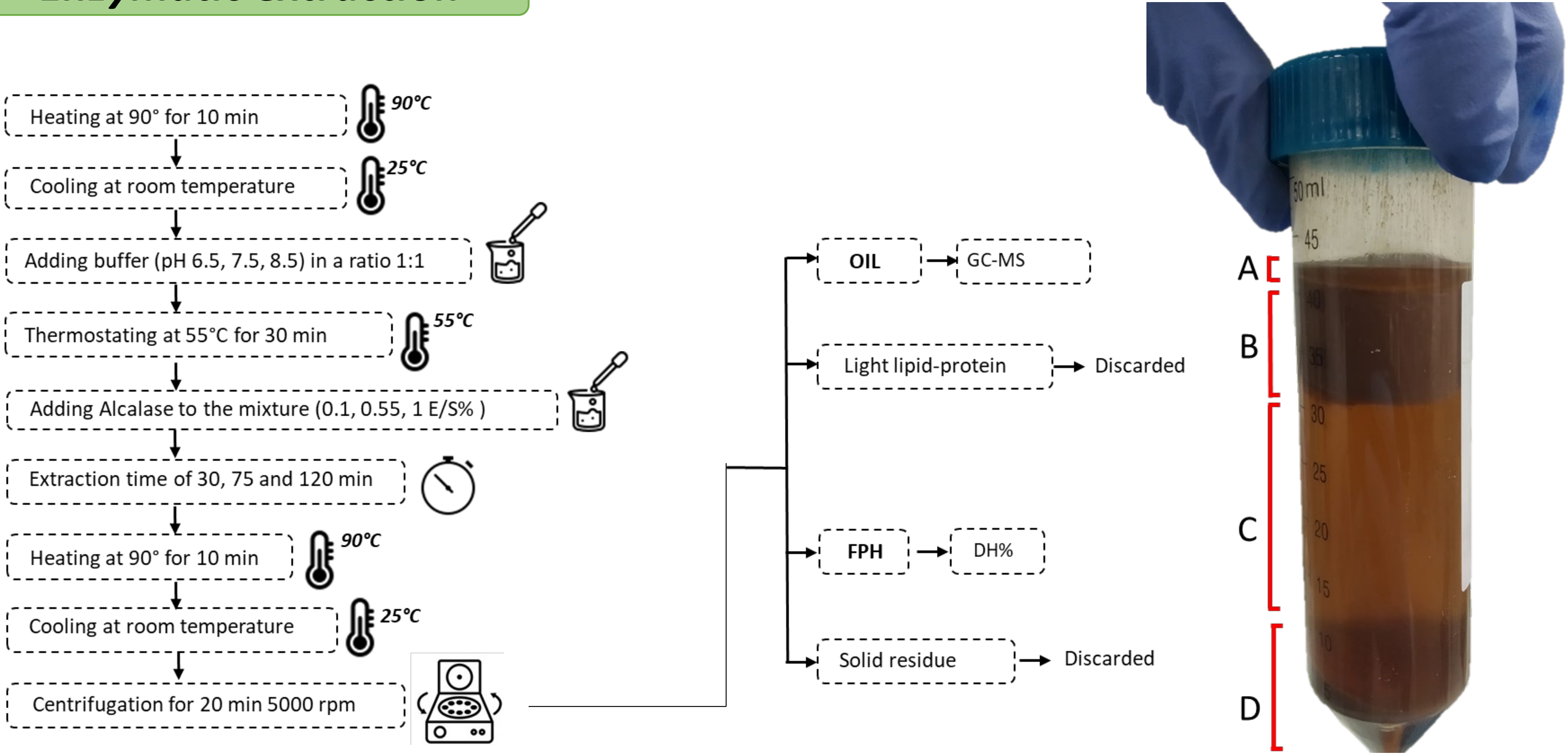

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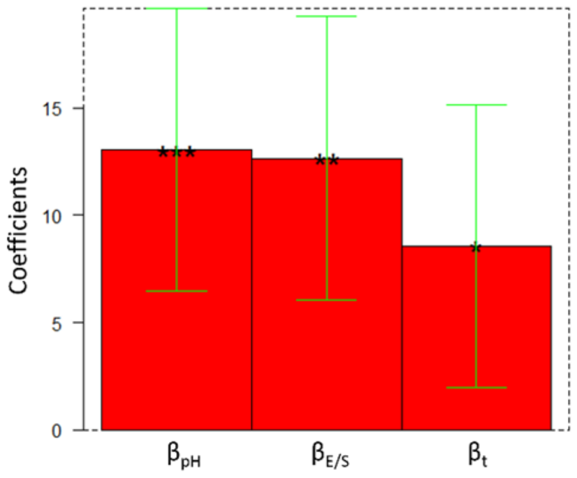
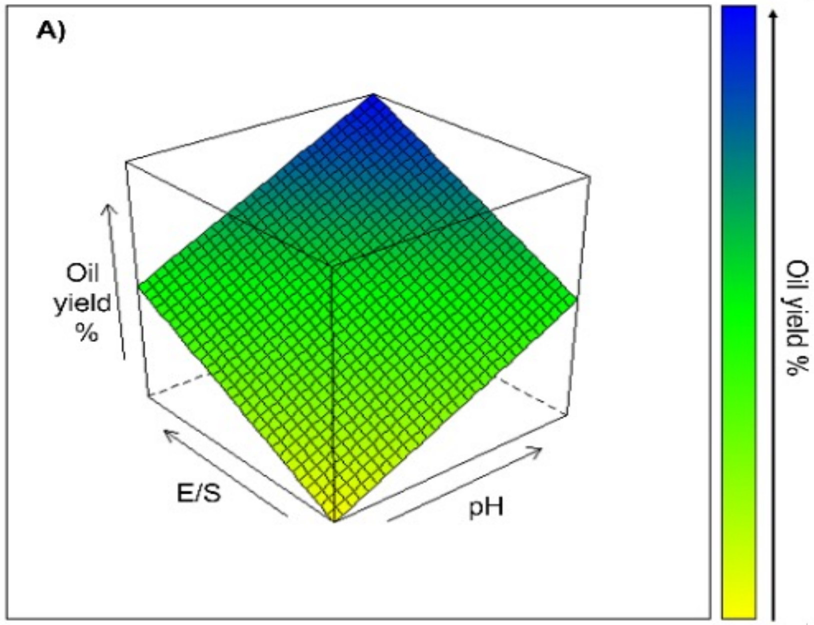
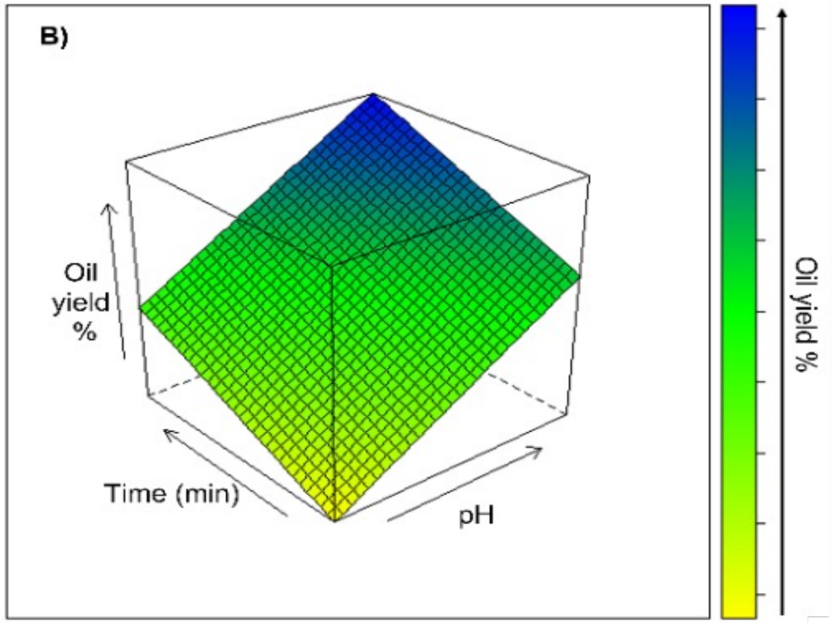
Valorization of tuna viscera

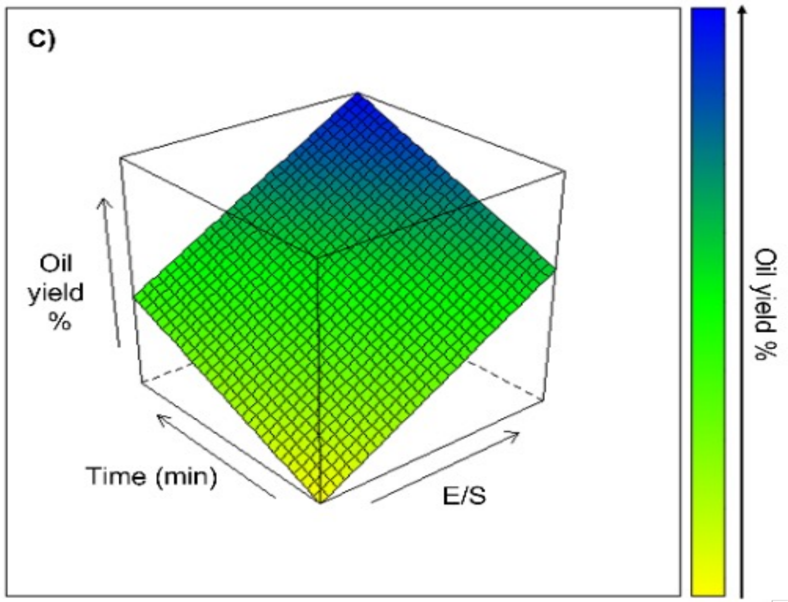
- ***Enzymatic extraction***

Response surface methodology (RSM)









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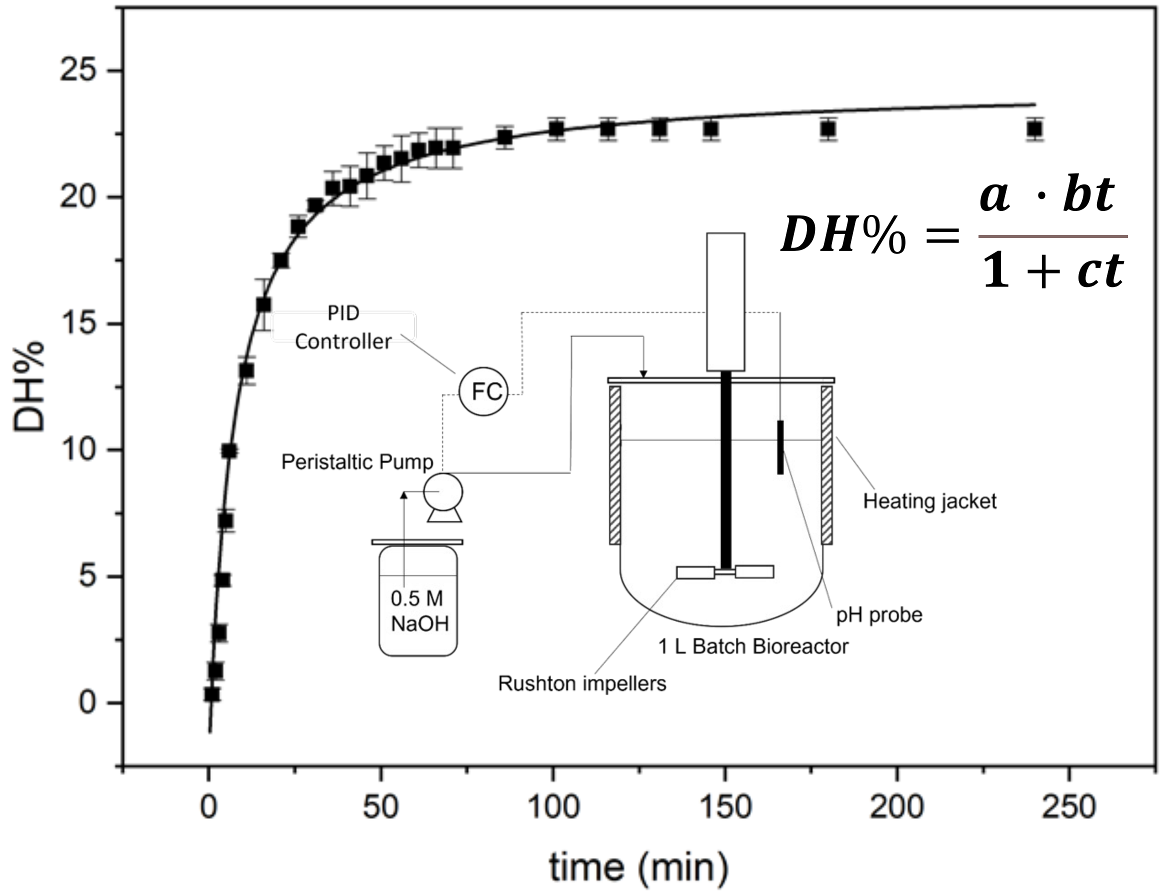
Valorization of tuna viscera

- *Enzymatic extraction*

Evaluation of the Progress of Protein Hydrolysis (pHstat method)



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Valorization of tuna viscera

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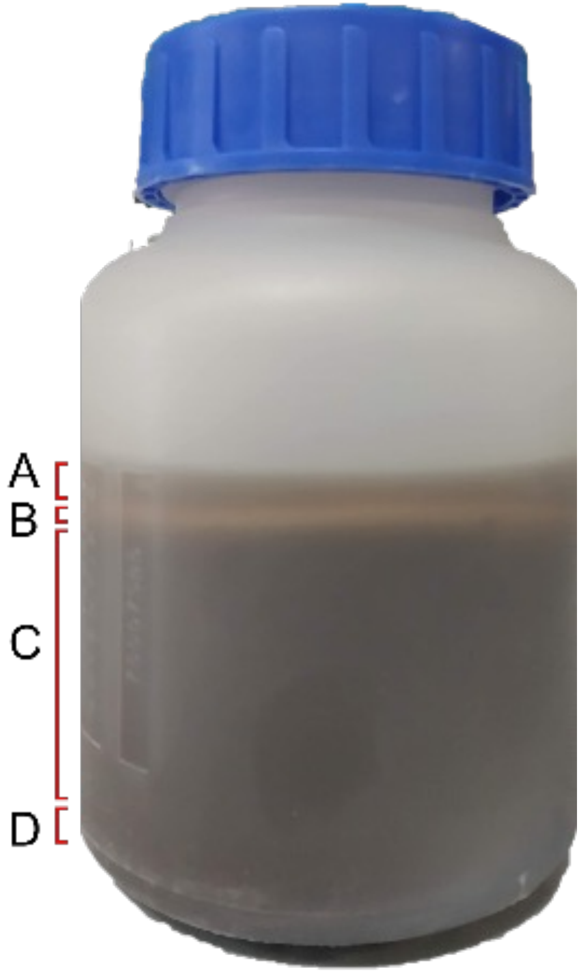

	EPA		DHA	
mg/g of oil	24,86	± 3,16	108,27	±11,35
%	2,49	± 0,32	10,83	±1,13

EPA and DHA contribute to preventing some cardiovascular and various inflammatory diseases such as hyperlipidemia, atherosclerosis and cancer, and present some beneficial effects on the nervous system

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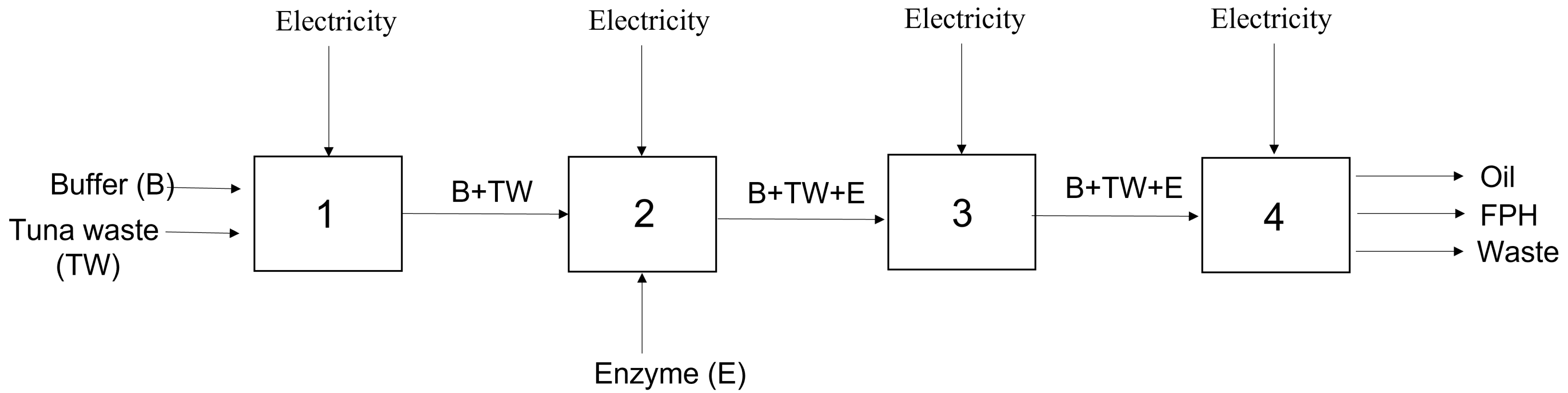
Valorization of tuna viscera

- *Enzymatic extraction*

LCA comparison (DoE experiments)



Impact category:

Climate change (kg CO_2 eq)

Ozone depletion (kg CFC-11 eq)

Freshwater eutrophication (kg P eq)

Marine eutrophication (kg N eq) and

Terrestrial acidification (kg SO_2 eq)

- **Software:** SimaPro 9.0.48
- **Database:** Ecoinvent 3.0.
- **Goal:** Choose the best extraction condition in term of environmental sustainability
- **Functional unit (FU):** 1 g of fish oil produced
- **Method:** ReCIPE Midpoint (H)

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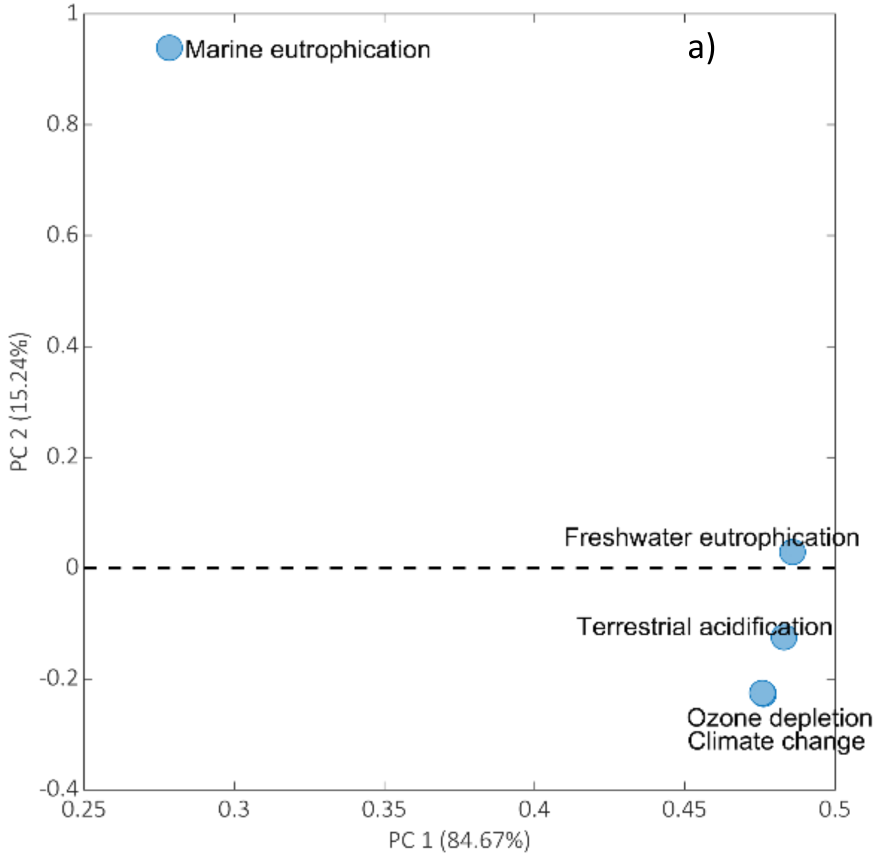
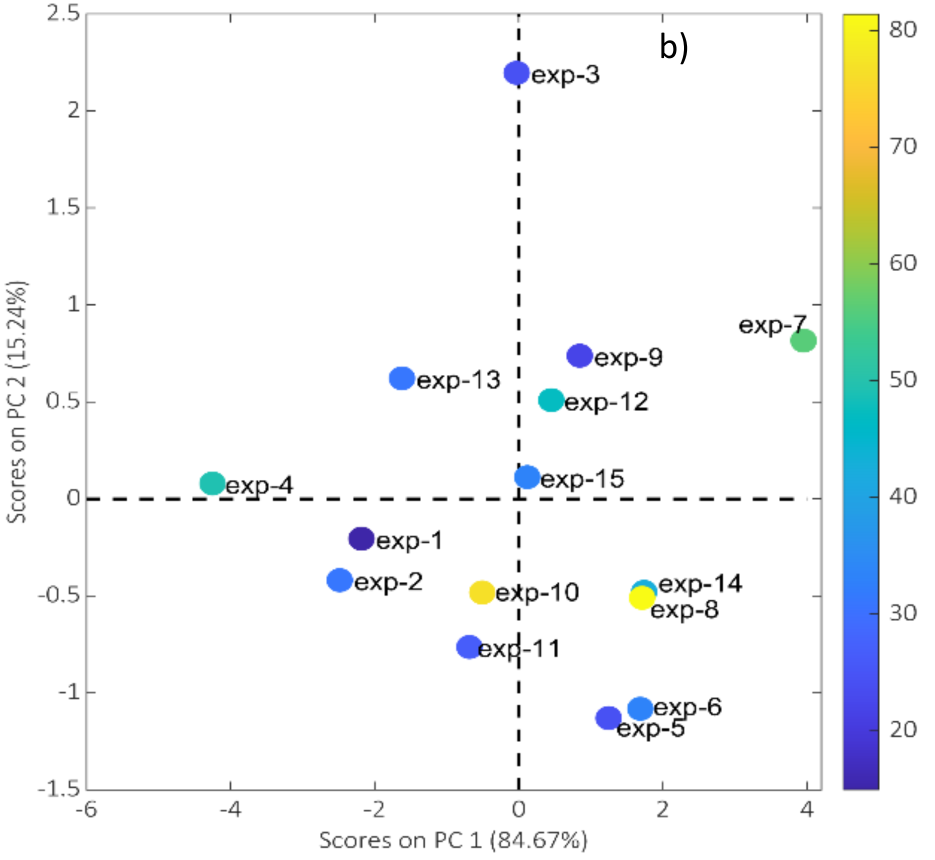
Valorization of tuna viscera

- ***Enzymatic extraction***

PCA (LCA-DoE experiments)

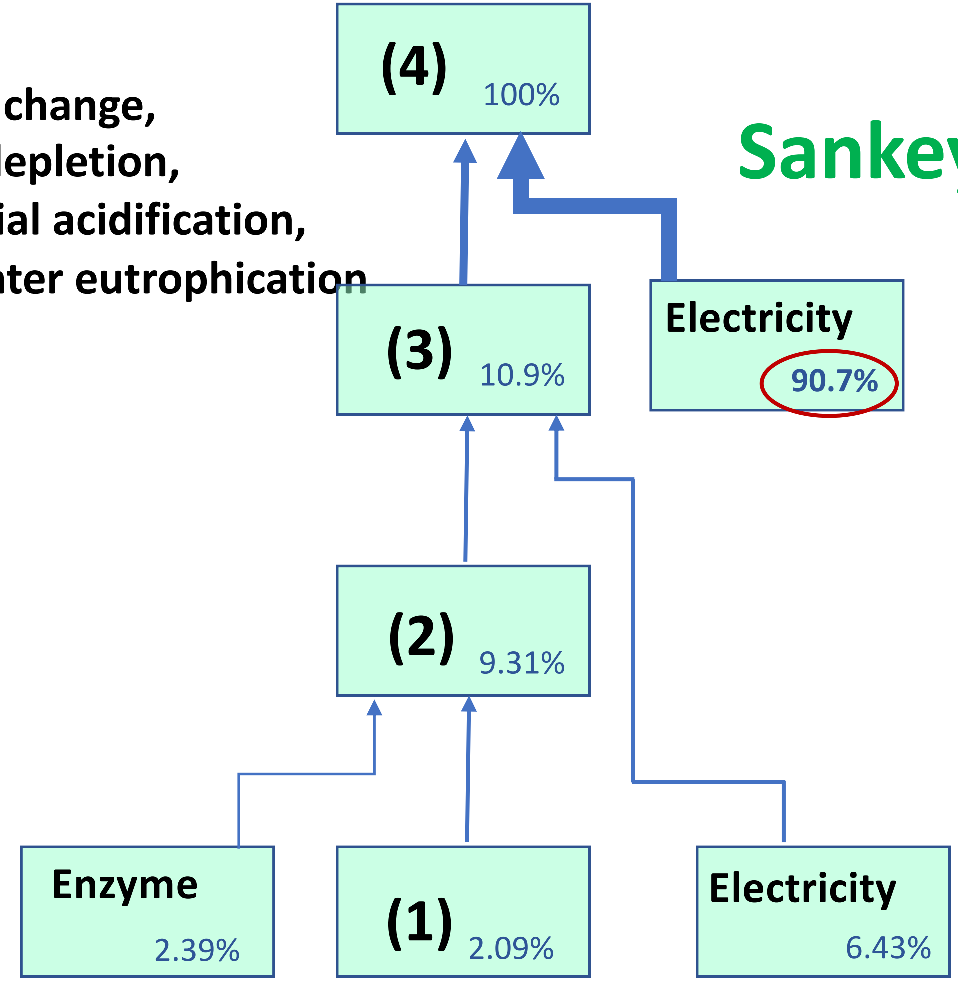




Valorization of tuna viscera

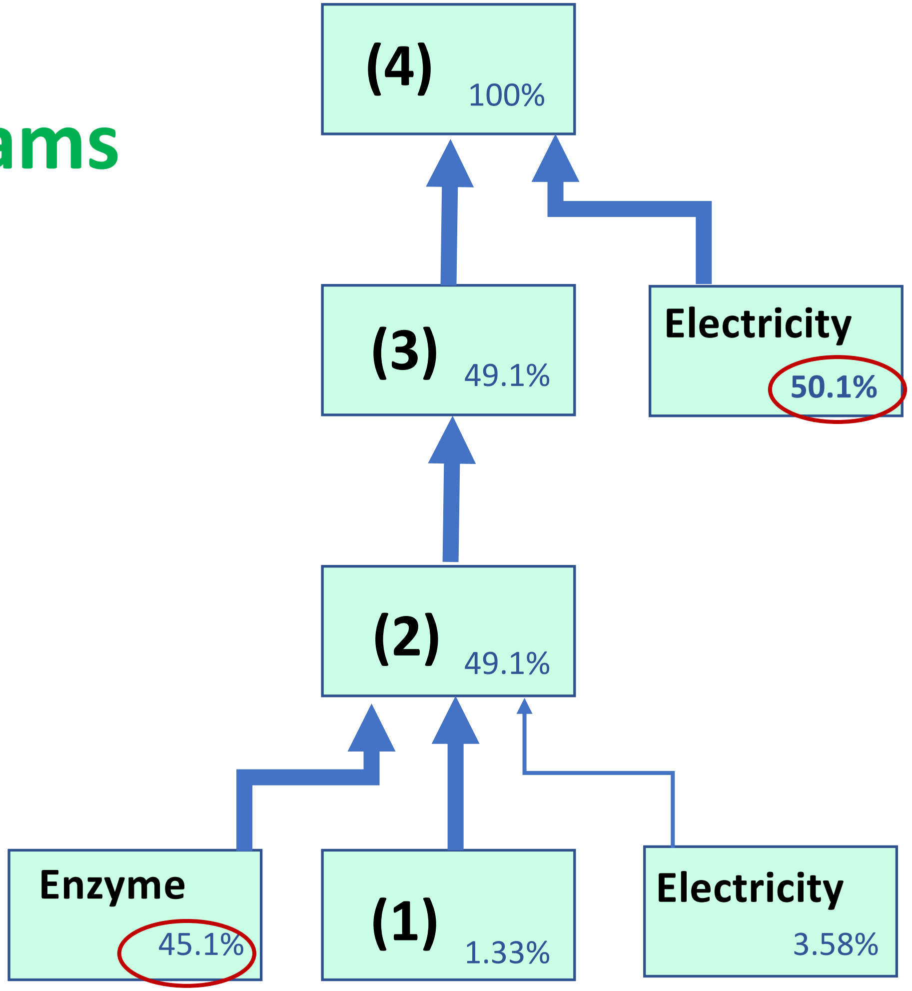
- *Enzymatic extraction*

Climate change,
Ozone depletion,
Terrestrial acidification,
Freshwater eutrophication



Sankey Diagrams

Marine eutrophication



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• *Conclusions*

- Enzymatic extraction with alcalase is suitable for extracting oil and FPH from tuna viscera
- The higher oil yield is obtained at pH 8.5 and E/S=1
- The reaction kinetics showed that hydrolysis reaches a steady state after one hour
- LCA confirms the results obtained by the DoE.
- To increase the sustainability of the process it is necessary to reduce the reaction times or to use renewable energy

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Acknowledgements

Thanks for your attention!

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