Assessing the ability of fishery by-products to contribute to the quality marine ingredient supply in the UK

Jean PEIGNON – August 2016

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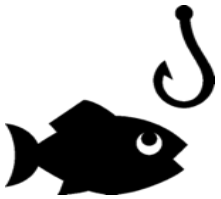
Context

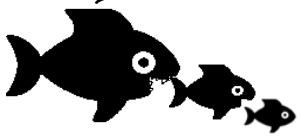
UK is the biggest fish processor in Europe



Stagnation of wild fisheries

Aquaculture annual growth +7,5%

Discard at sea, due to lack of incentive



Marine ingredients are essentials for aquafeed

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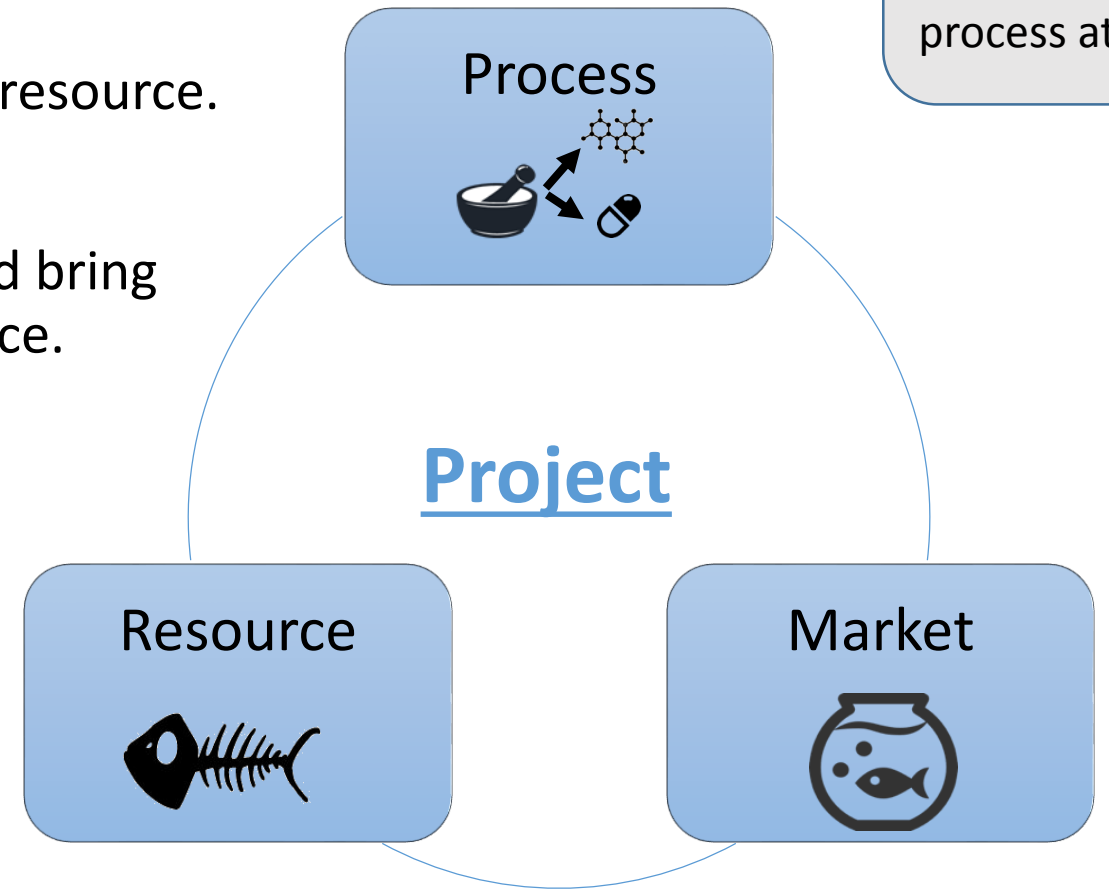
Our approach

- **Quantitative:**

Understand where is the resource.

- **Qualitative:**

Understand how we could bring more value to this resource.



What is the most suitable one to create the value?
Write a protocol and perform the process at the IoA.

Availabilities:
- What?
- Where?
- When?

Current uses:
- What uses?
- By whom?

Understand the marine ingredients market: from the production to the end users (aquafeed manufacturers).

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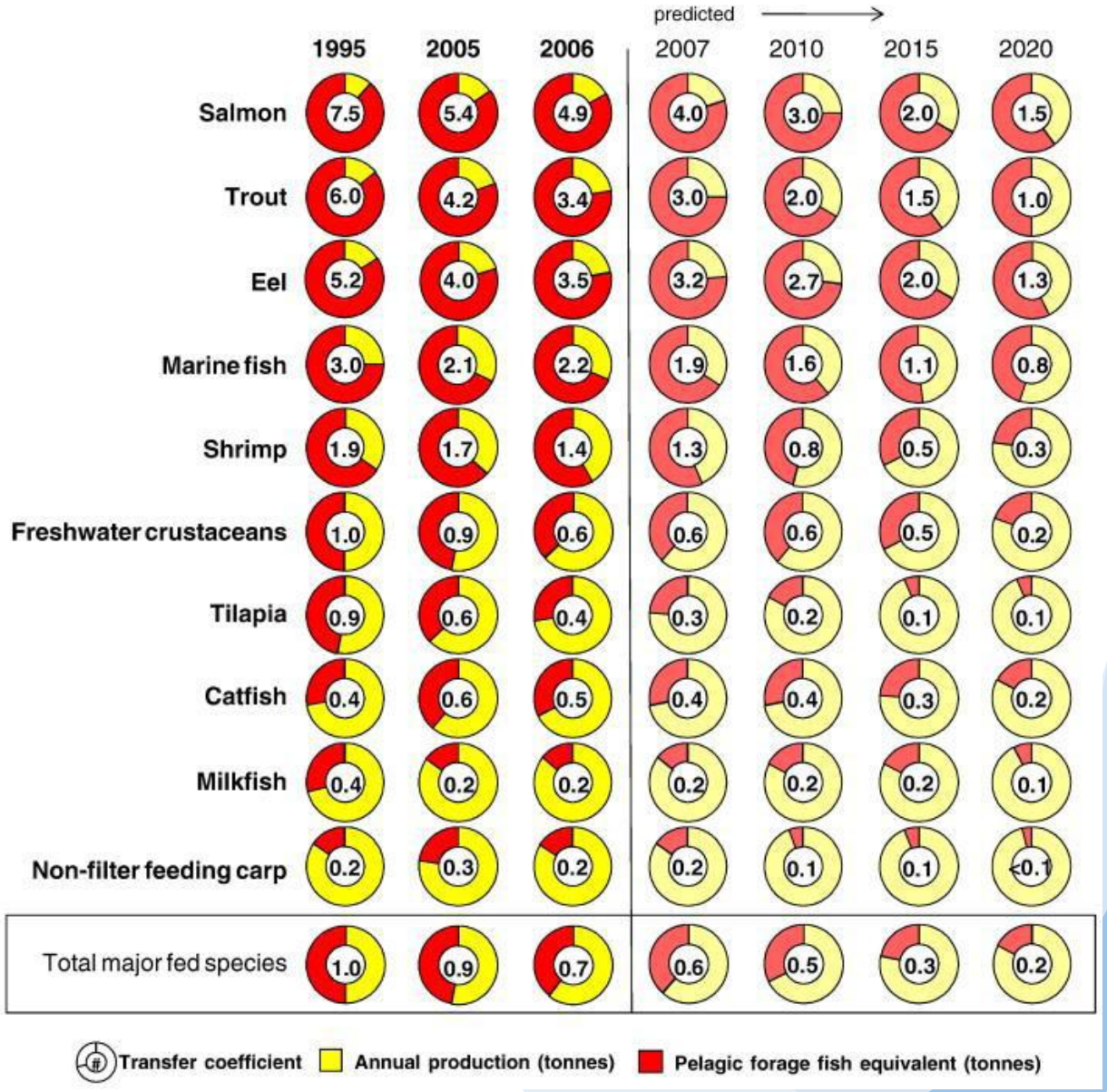
Market - FM consumption and replacement

- The aquaculture formulation changed to contain FM at it's minimum requirement, leading to a substitution
- Substitution requires to improve, not only the knowledge on the traditional essential nutrients but also the effects of minor nutrients.
- These minor nutrients have to be brought somehow in small quantities in the formulation.



Market – Marine ingredients perception

- Marine ingredients are now considered as **functional ingredients**:
  "an ingredient which delivers additional or enhanced benefits over and above their basic nutritional value"

E.g. Attractants, micro minerals, pigments, bioactive molecules etc.

- The basic nutritional requirements are covered by a portfolio of cheaper materials to guarantee a competitive price and quality.

Functionality being the keyword, our aim was to find a process enhance the functionality of fisheries by-products.

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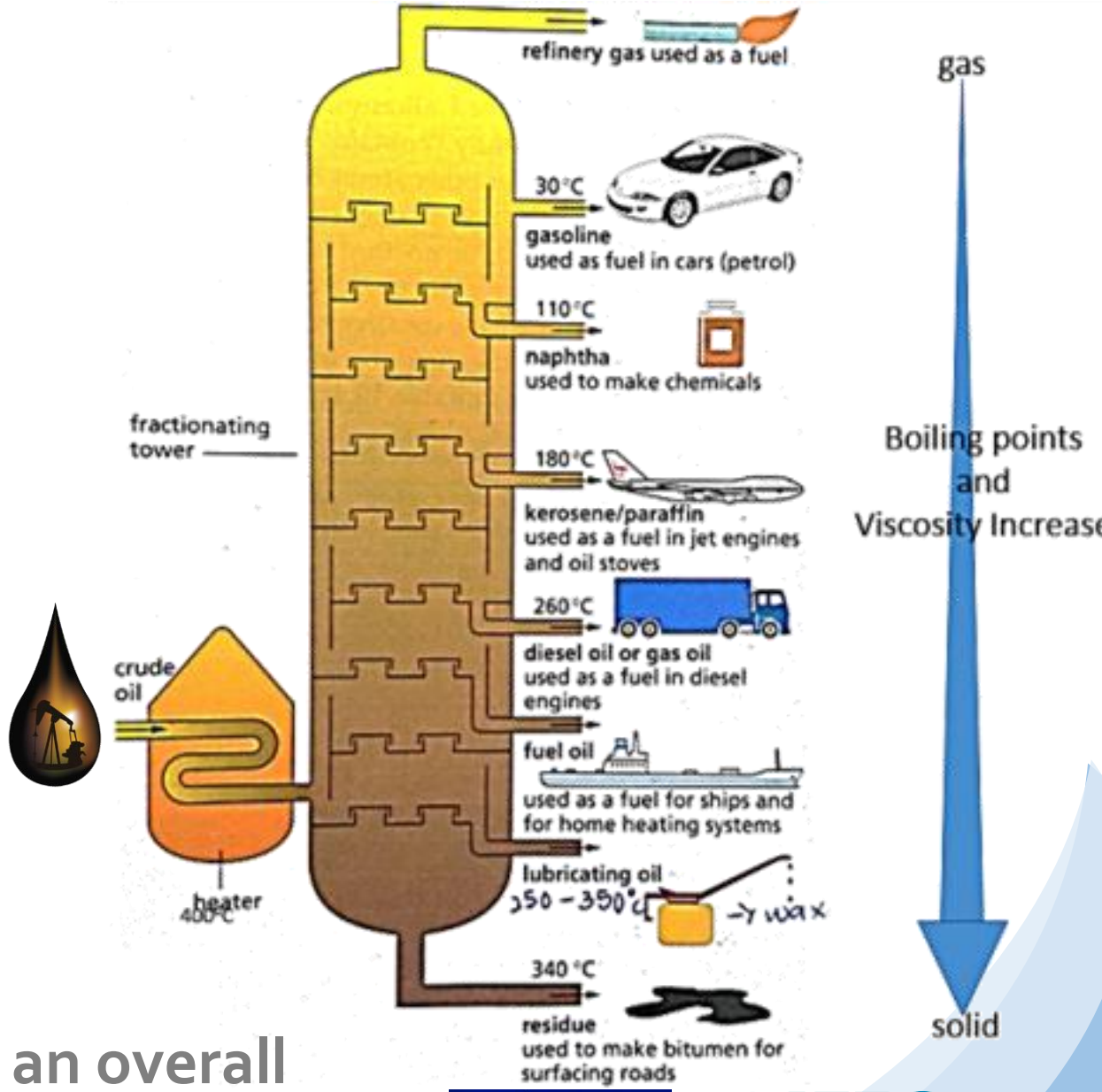
Process - Selection

- The approach was based on the refining model from the petroleum industry.
- The major idea being to find a non-destructive process which separates the raw material into several phases.
- These phases can then be concentrated and used independently to fulfil specific role in the formulation.



"Cracking" a complex product fulfilling an overall use to produce specific products for specific uses.

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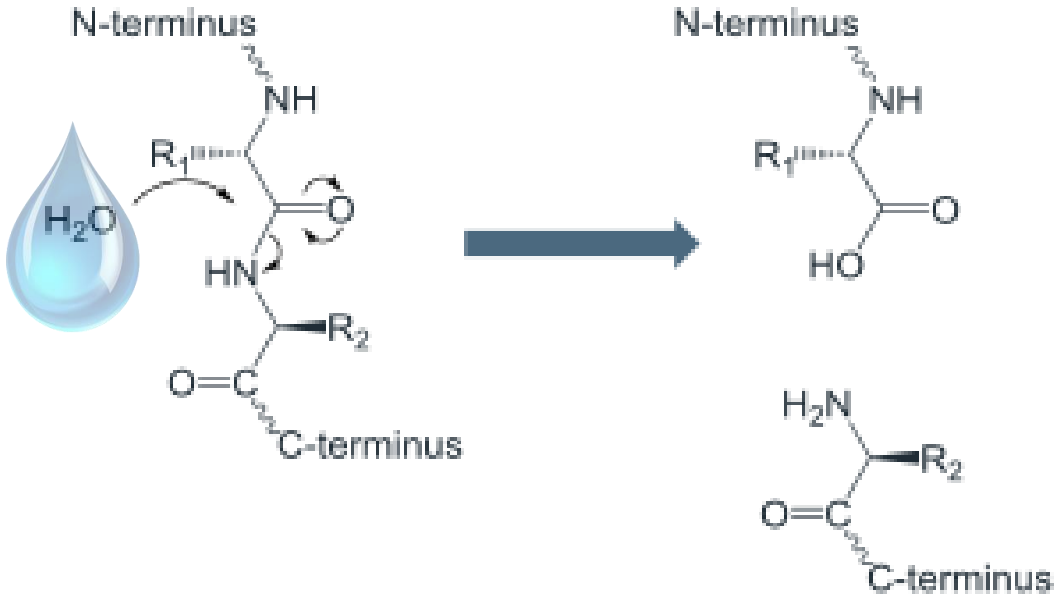
Process –Proteolysis



- The process selected is **proteolysis**:

"The breakdown of proteins into smaller polypeptides or amino acids. Proteolysis is typically catalysed by enzymes called proteases".

- Proteolysis is a **specific reaction** which does not alter the rest of the raw materials and allow the implementation of the refining model.

- Several authors highlighted the interest of hydrolysates both as a tool for an **effective fishmeal replacement and proven effect on fish health and growth**.

- Proteolysis is already used at industrial scale to produce protein concentrates.

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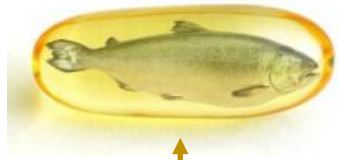
Industrial Fishmeal and hydrolysis processes

Raw Materials

Cooking → Pressing → Drying → Milling

Pressing → Solid recovery → Oil recovery → Evaporating → Drying



Mixing → Hydrolysis → Centrifugation → Concentration → Drying

Enzyme → Hydrolysis

Hydrolysis → Stabilization → Concentration

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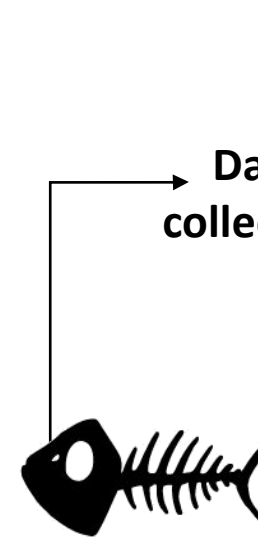
Process – Hydrolysis protocol at the IoA



Raw material

Data collection

Grinding

Freeze dried

Moisture
Oil
Protein
Ash

Enzymatic hydrolysis

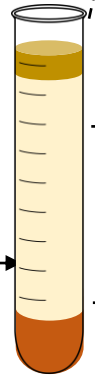
Sampling over time

0’ → Centrifuge

20’

40’

240’



Lipid layer (If available) → Fatty acid analysis

Supernatant → Liquid → α- amino acid concentration

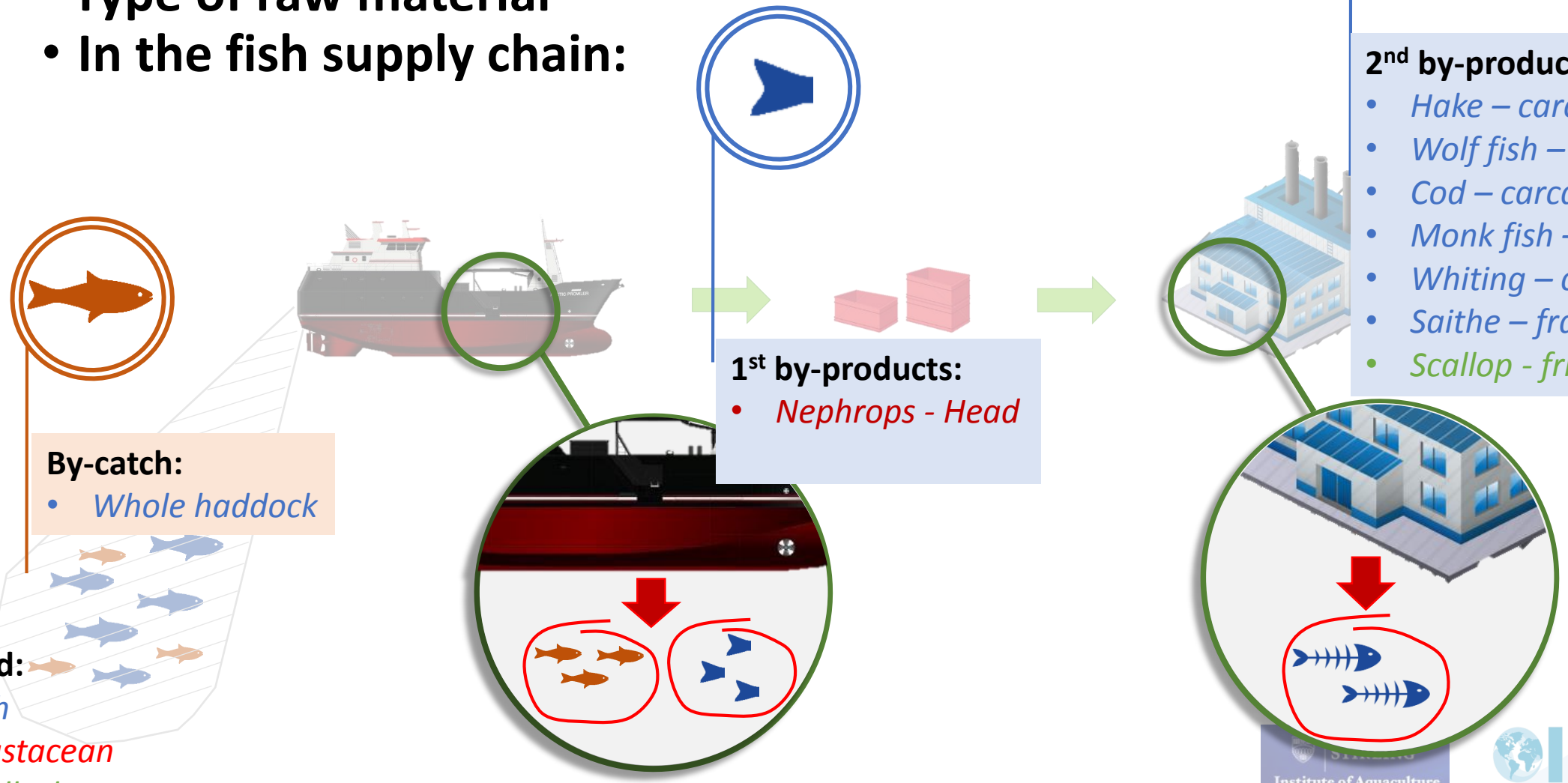
Freeze dried → Moisture
Oil
Protein

Sludge → Freeze dried → Mineral composition

Raw material - sampling

We aimed to be representative both in term of :

- **Type of raw material**
- **In the fish supply chain:**



By-catch:
- *Whole haddock*

1st by-products:
- *Nephrops - Head*

2nd by-products:
- *Hake – carcass*
- *Wolf fish – carcass*
- *Cod – carcass*
- *Monk fish – head*
- *Whiting – carcass*
- *Saithe – frame*
- *Scallop - frills*

Legend:
- *Fish*
- *Crustacean*
- *Mollusk*

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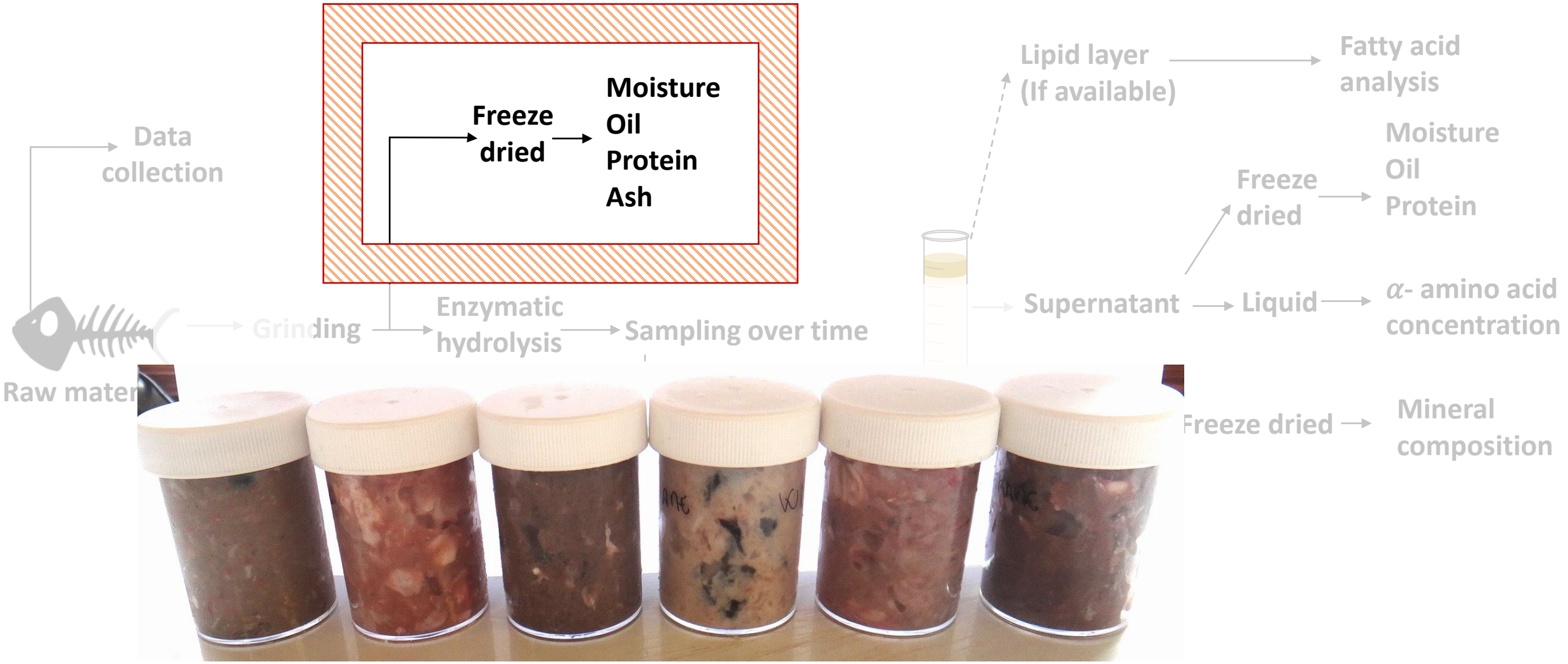
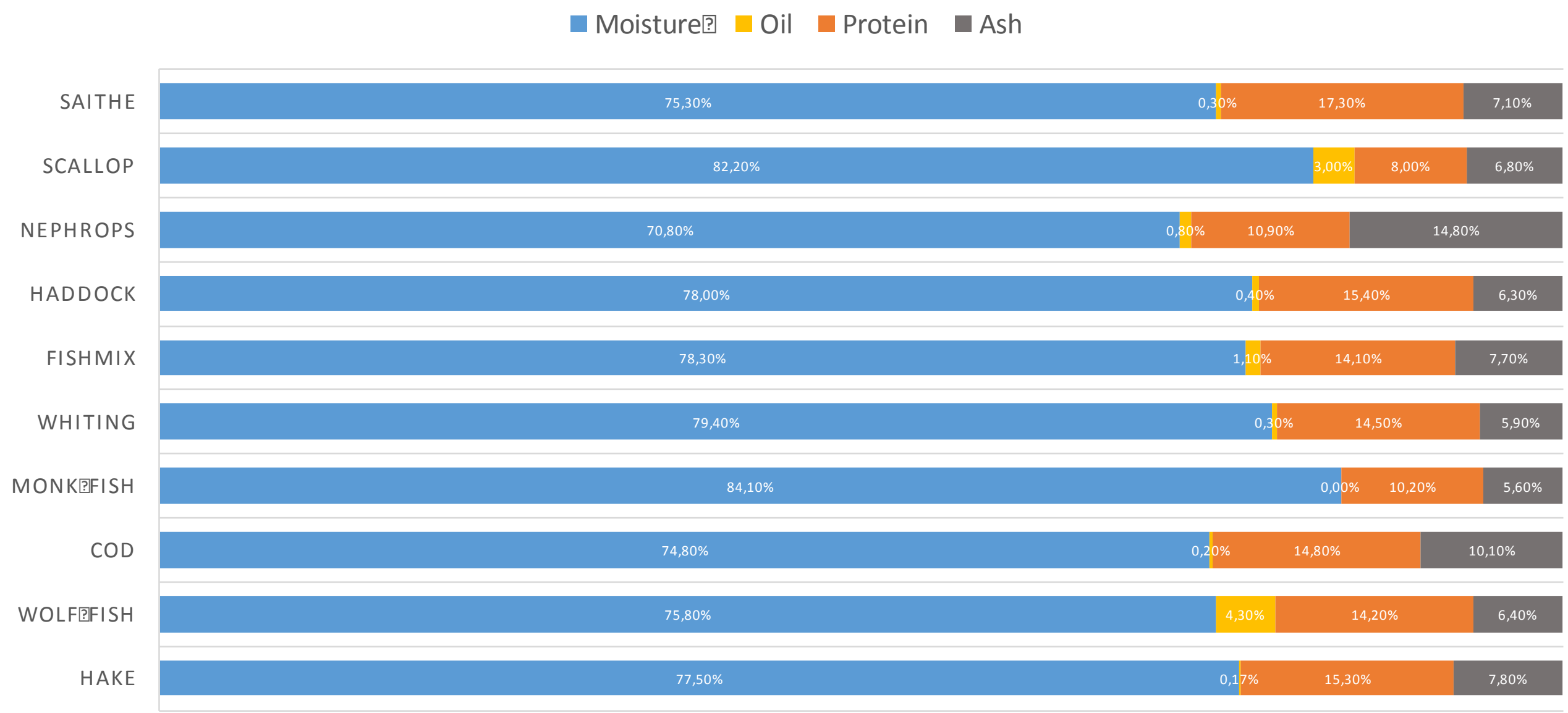
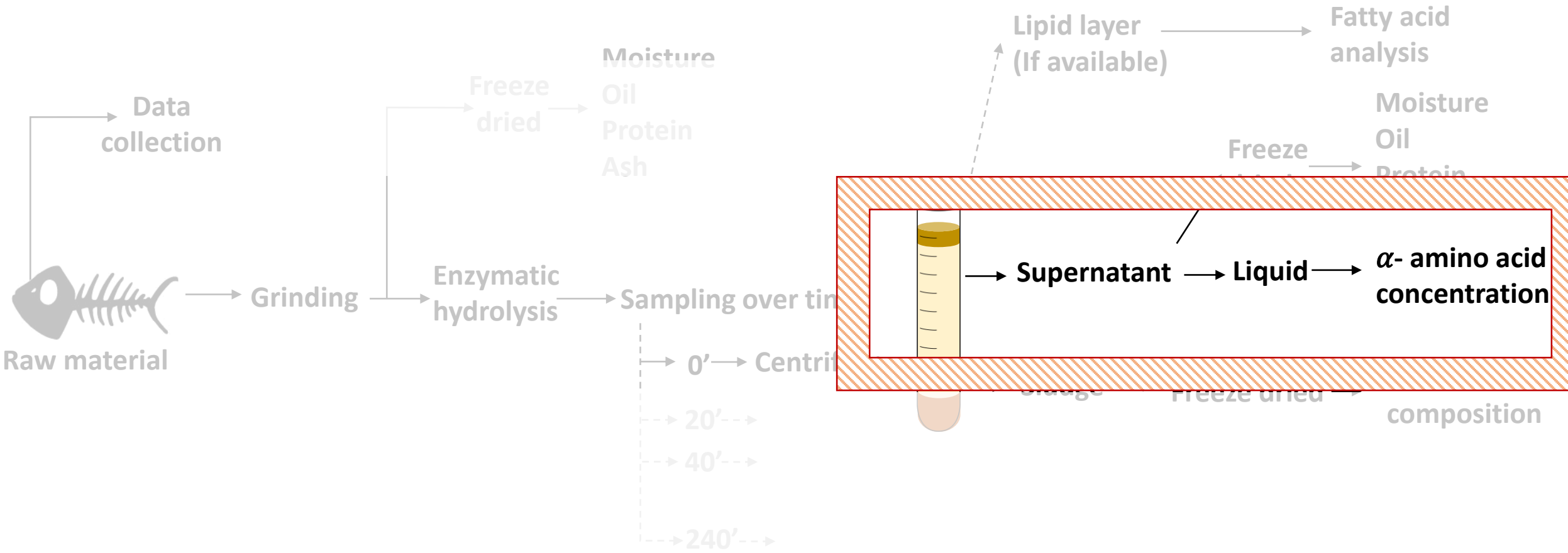
Raw material- Proximal analysis



Raw material- Proximal analysis

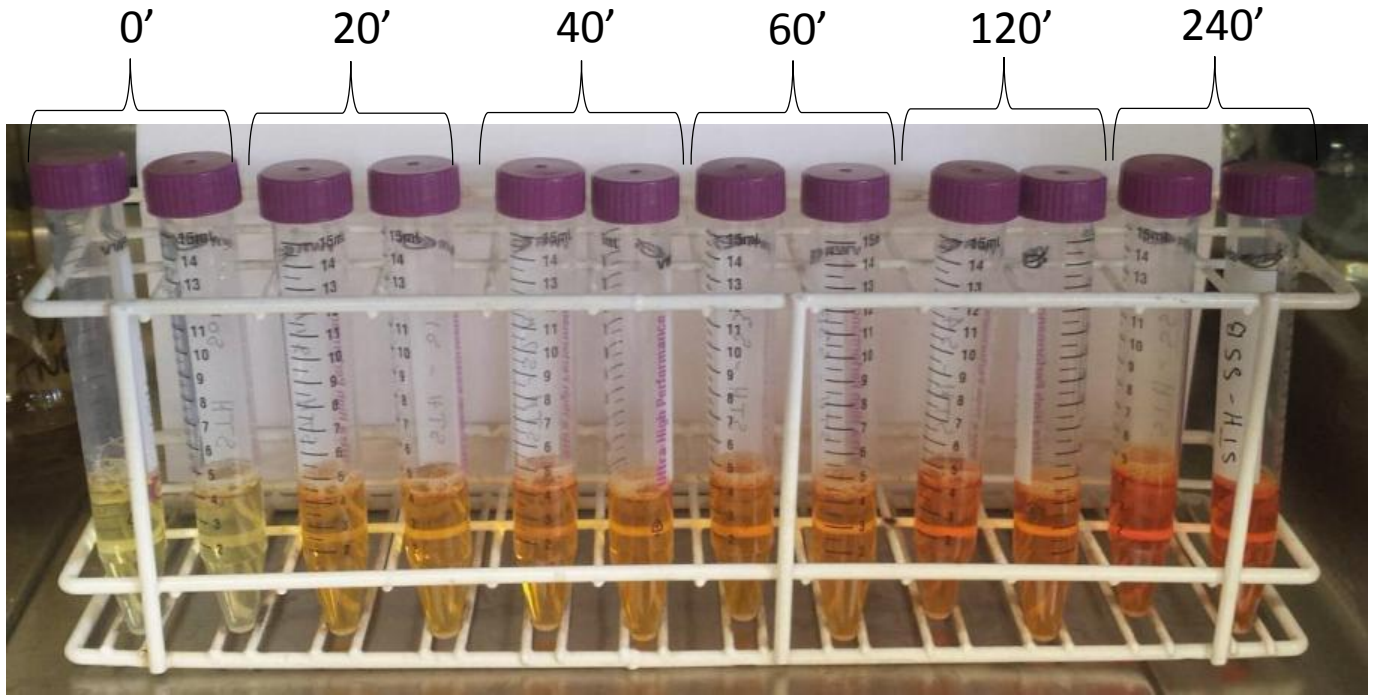


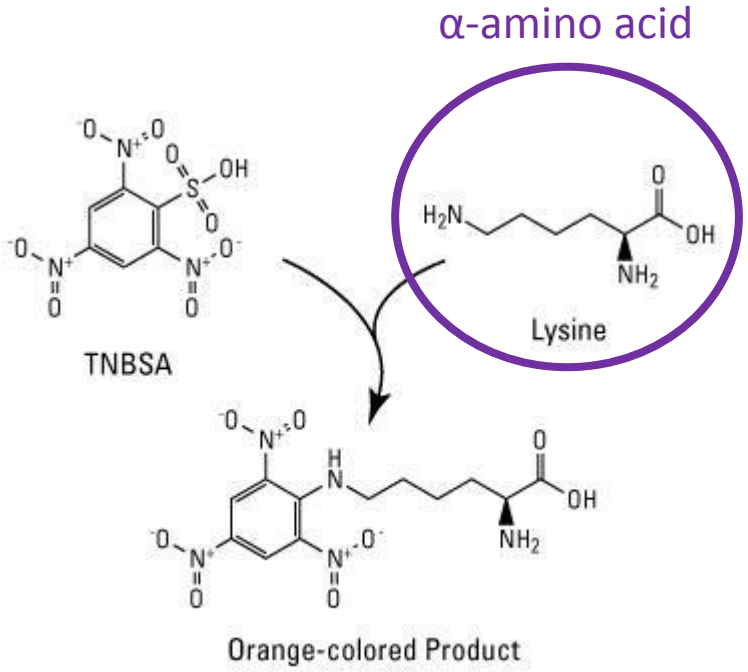
Process – α-amino acid concentration



Process – α-amino acid concentration

- The breakdown of proteins increases the amount of peptides and amino acids.
- TNBSA, which reacts with primary amines (peptides or amino acids), was used to measure there concentration in the different supernatant phase.





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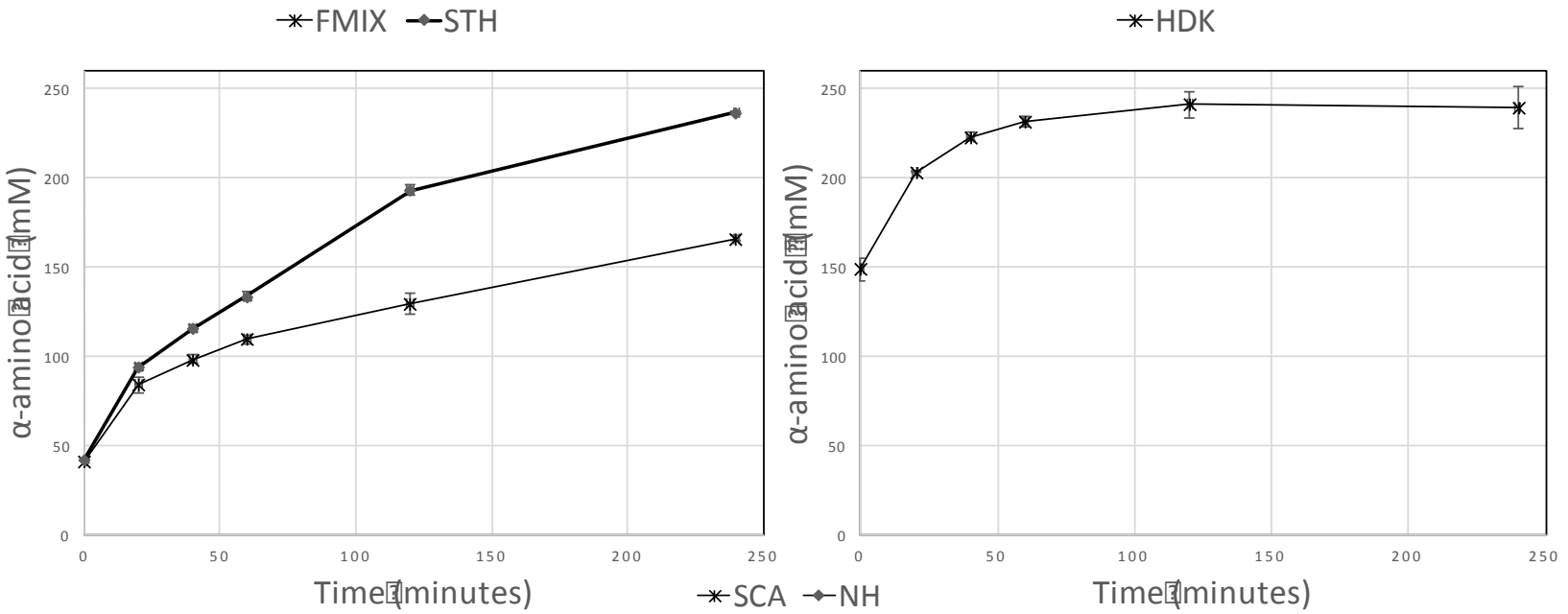
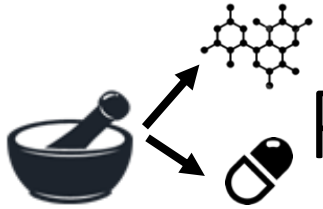
Process – α-amino acid concentration





Process – α-amino acid concentration

- All the raw materials have an increase of α-amino acid concentration, showing that hydrolysis did occur, and flatten to the top accordingly to others results.

- The initial concentration are different between the raw materials. This results could be explained by two characteristics:
  - the freshness and storage conditions.
  - the presence of soft tissues and endogenous enzymes within the raw materials.

Freshness and storage condition appeared to be critical points

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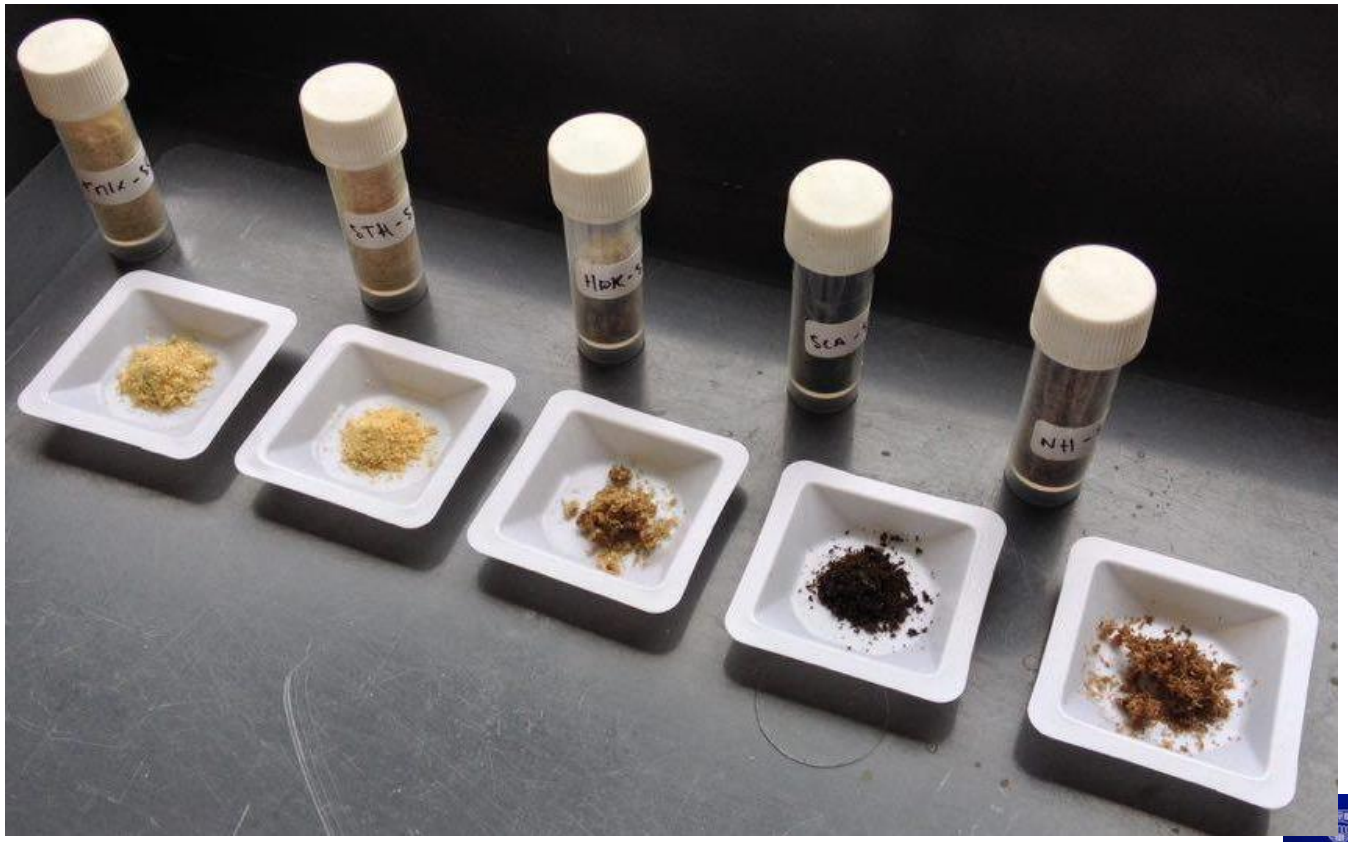
Process – Yield

- As it was the starting point of the α-amino acid plateau, 60 minutes was chosen to be the optimum point. All the result showed after are based at this time.



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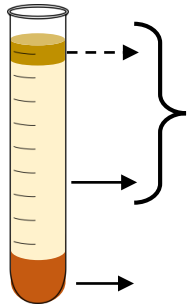
Process – Yield

Haddock - Whole

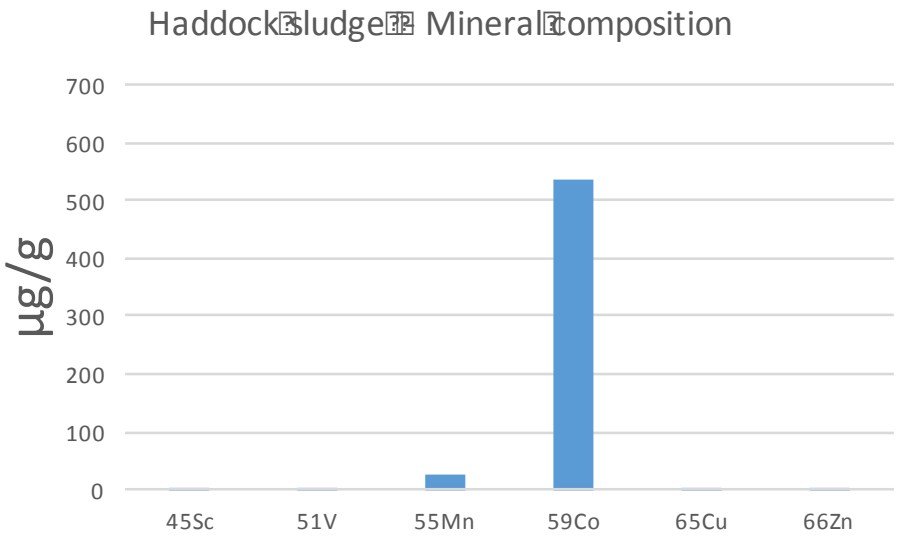


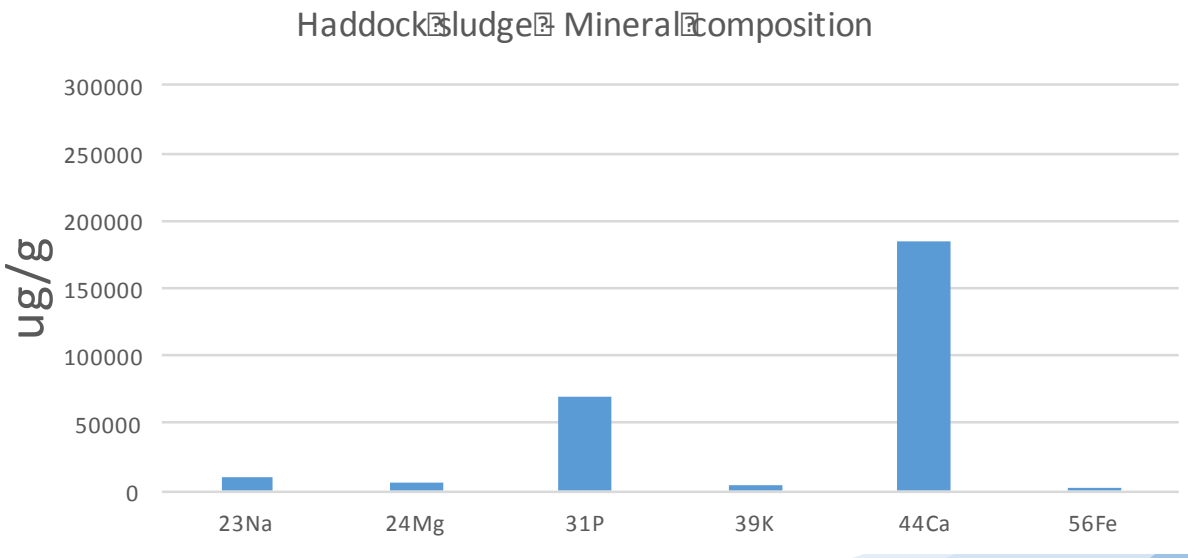
Freeze dried supernatant + lipid

Yield (kg/kg of raw material)	% of protein	% of lipid
0,145	77%	>1%

Solid Sludge

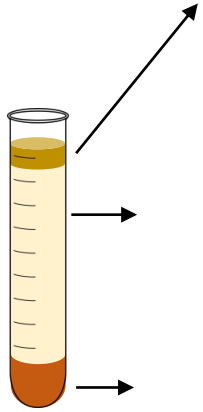
Yield (kg/kg of raw material)
0,09





Process – Yield

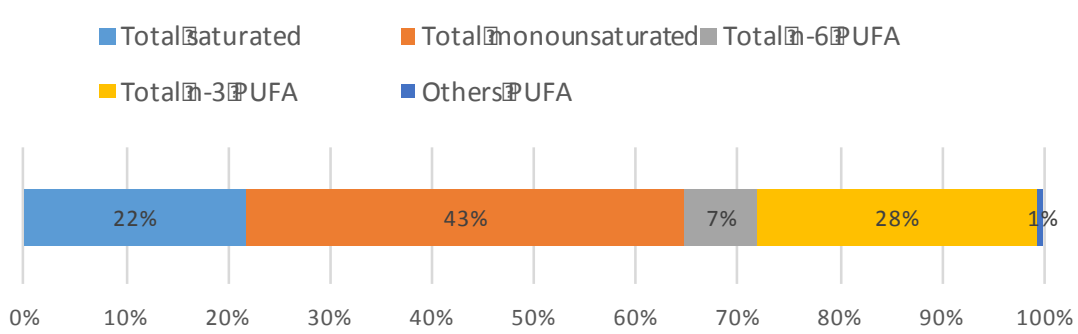
Nephrops - Head



Lipid layer

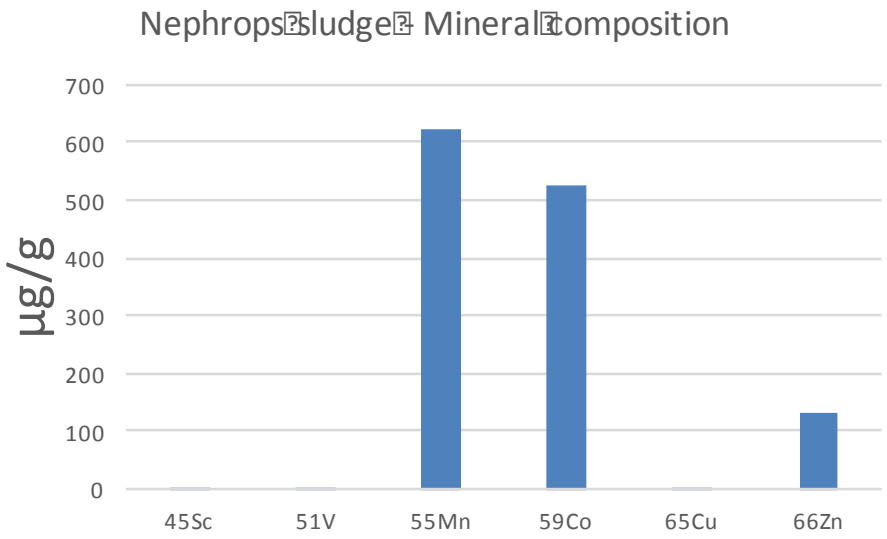
Freeze dried supernatant

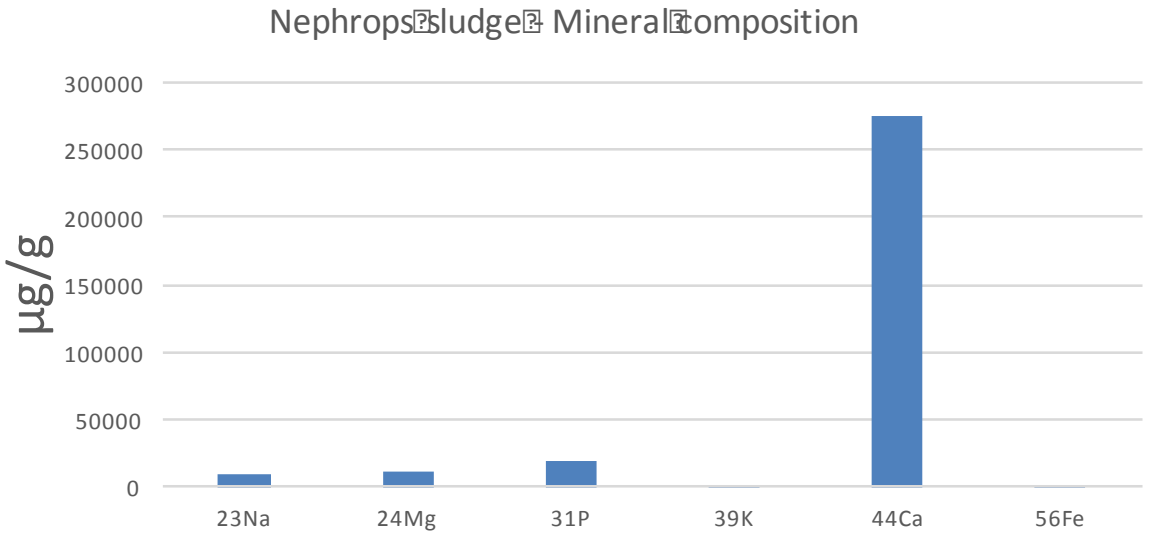
Solid Sludge



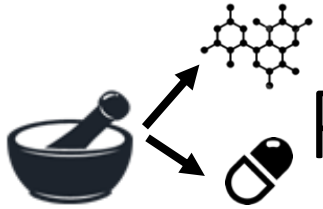
Yield (kg/kg of raw material)	% of protein	% of lipid
0,106	62%	>1%

Yield (kg/kg of raw material)
0,35

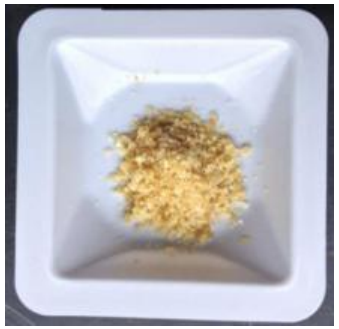


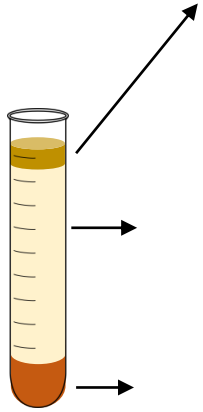


Process – Yield



FishMix - Carcass

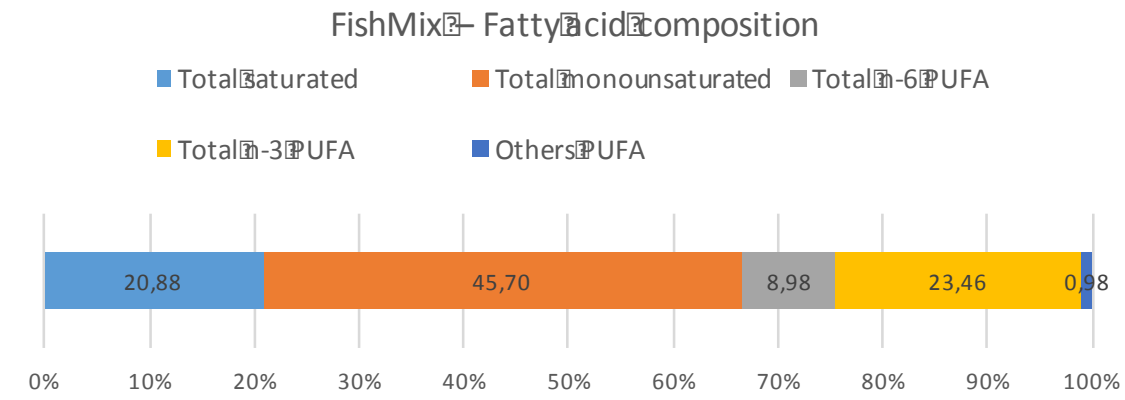




Lipid layer

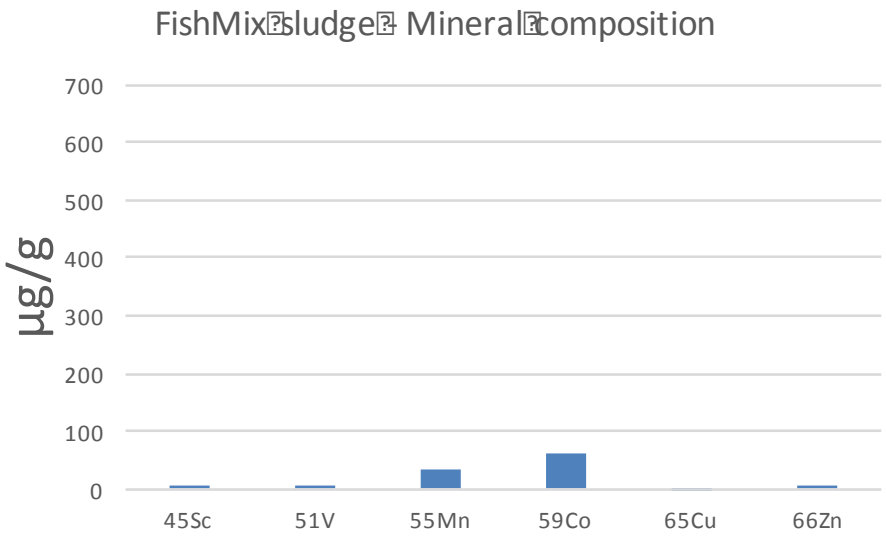
Freeze dried supernatant

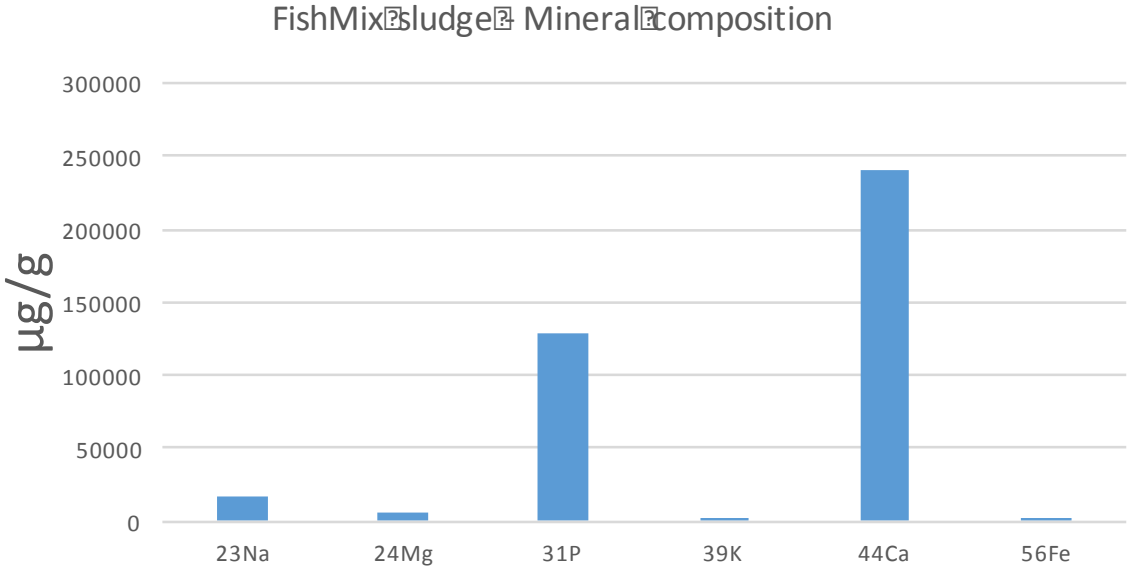
Solid Sludge



Yield (kg/kg of raw material)	% of protein	% of lipid
0,114	83%	1,4%

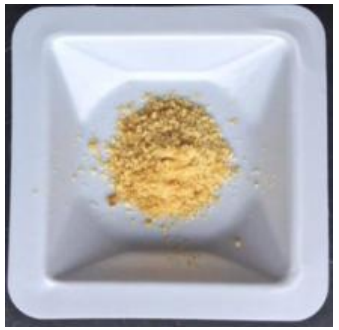
Yield (kg/kg of raw material)
0,35

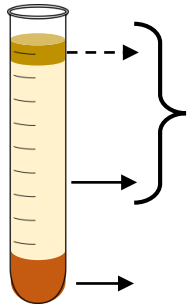




Process – Yield

Saithe - Frame





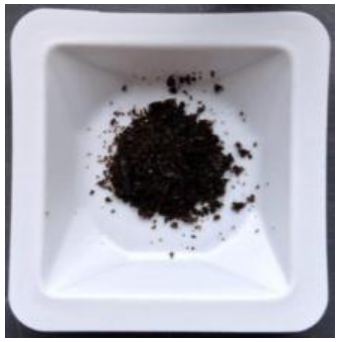
Freeze dried supernatant + lipid

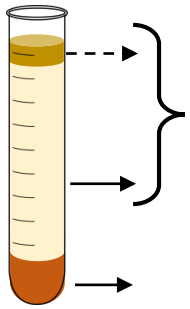
Solid Sludge

Yield (kg/kg of raw material)	% of protein	% of lipid
0,112	88%	<1%

Yield (kg/kg of raw material)
0,15

Scallop - Frills





Freeze dried supernatant + lipid

Solid Sludge

Yield (kg/kg of raw material)	% of protein	% of lipid
0,106	62%	7,9%

Yield (kg/kg of raw material)
0,10

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Process – Remark

- Pigments could not be treated, but they represent an very interesting functional part of the raw materials, especially for the nephrops.

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Market - Potential

- The hydrolysates are meant to be used in a diet formulation. As we had no time to try them in-vivo, we will use the following article's and our lab trial's result to "simulate" an in-vivo trial and compare utilisation of hydrolysate vs. fishmeal formulation.

Fish & Shellfish Immunology 45 (2015) 858–868

Contents lists available at ScienceDirect

Fish & Shellfish Immunology

journal homepage: www.elsevier.com/locate/fsi

Full length article

Effects of protein hydrolysates supplementation in low fish meal diets on growth performance, innate immunity and disease resistance of red sea bream *Pagrus major*

Sanaz Khosravi [a], Samad Rahimnejad [a], Mikaël Herault [b], Vincent Fournier [b], Cho-Rong Lee [a], Hien Thi Dio Bui [a], Jun-Bum Jeong [c], Kyeong-Jun Lee [a, *]

[a] *Department of Marine Life Sciences, Jeju National University, Jeju 690-756, South Korea*
[b] *Research & Development Aqua Platform, Aquativ Corporation, AQUATIV (DIANA, Member of SYMRISE Group), Elven, France*
[c] *Department of Aquatic Biomedical Science, Jeju National University, Jeju 690-756, South Korea*

Market - Potential

- The following article as been retained because it used industrial hydrolysates, both made with co-products, similar to the one we produced:
  - A tilapia hydrolysate (TH) at 95% dry matter and 71%CP, comparable to the FishMIX at 83% CP.
  - A shrimp hydrolysate (ST) at 96% dry matter and 64% CP, similar to nephrops head at 65% CP.

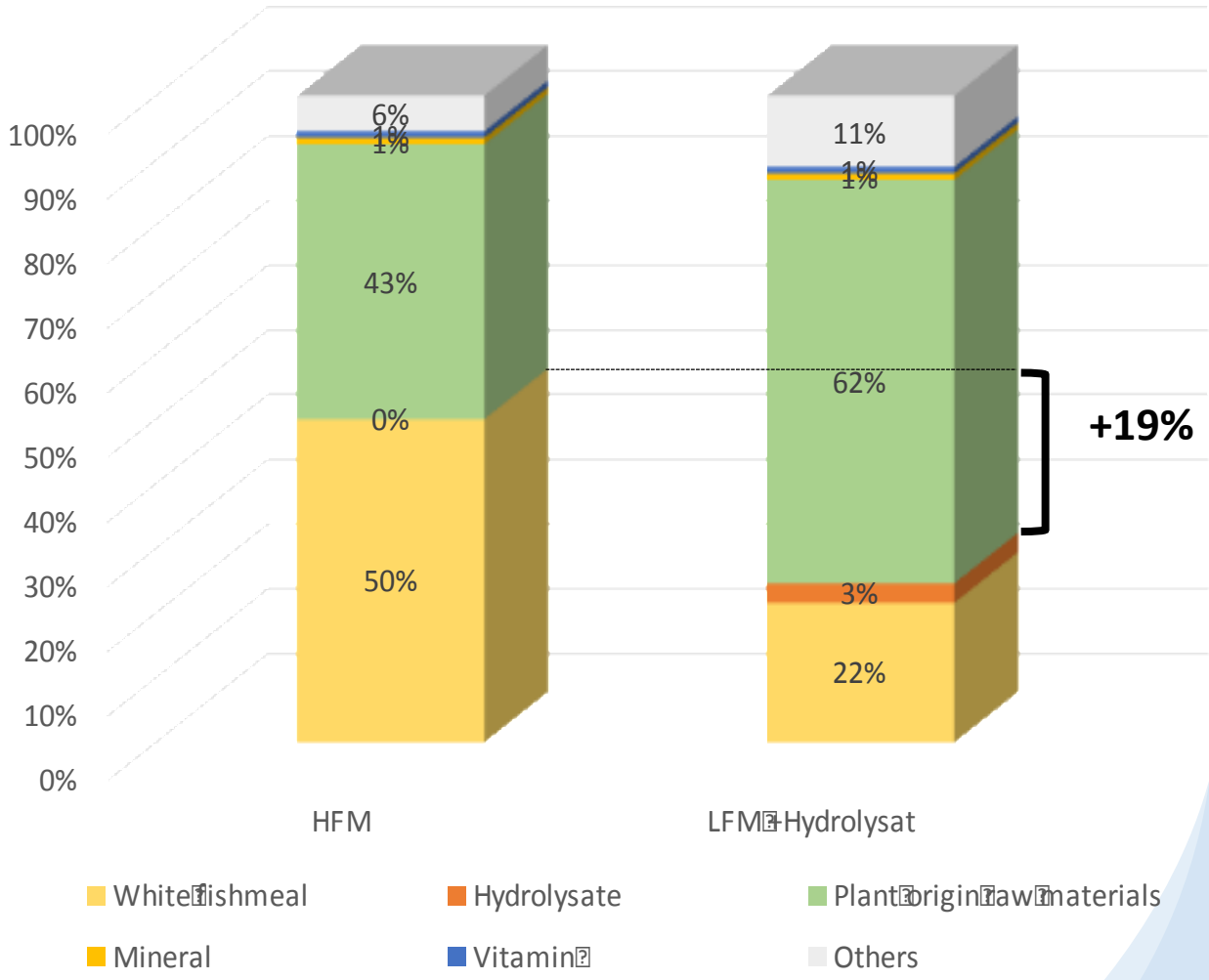
Red Seabream - *Pagrus major*

Market - Potential

The authors used two diets:

- a low fish meal diet (LFM) + 3% hydrolysate.
- high fish meal diet (HFM)

	HFM	LFM + Hydrolysate
White fishmeal	**50%**	**22%**
Hydrolysate	**0%**	**3%**
Plant origin ingredients	**43%**	**62%**
Mineral	1%	1%
Vitamin	1%	1%
Others	6%	11%



Market - Potential

- The authors found that LFM + 3% hydrolysates compared to HFM have better results in term of
  - *growth performance,*
  - *non-specific immune response*
  - *disease resistance*

- In this particular case, the results show a **more efficient use of the resource** for the low fish meal diet, as HFM consumes 80% more "equivalent raw material" than the LFM diet.

Kg of fish needed to to produce 1T of feed	HFM diet	LFM diet
Fishmeal (kg)	2222	960
Hydrolysates (kg)	0	273
Total (kg)	**2222**	**1233**

Note: As it is not destructive, the hydrolysis process will not impact the overall oil yield per kg of raw material compared to fishmeal/fish oil process.

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Market - Potential

These results advocate the interest of hydrolysis as a mean to improve:

- **the zootechnical performances of juvenile red sea bream *Pagrus major***
- **the efficient use of a limited resource.**

All in tune with the aquafeed industry diversification strategy.

Conclusion

- The refining model appeared to be “in tune” with the UK aquafeed market. The next step would be to run **in-vivo trials** to measure their effects in order **to assess the market value of these products.**

- **Increased market value** could allow to create more **economical incentive to the UK fishermen** and therefor **“unlock”** the substantial amount of raw materials which are discarded at sea.

- The hydrolysates, under certain conditions, can help to **use more efficiently a limited resource.**

- Finally, this project opened up lines of thought about **the potential of marine hydrolysates to create a circular economy within the UK seafood industry.**

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