RECOVERY OF BIOMOLECULES FROM LIQUID SIDE-STREAMS FROM MUSSEL PROCESSING

Mónica Gutiérrez, Bruno Iñarra, David San Martin & Carlos Bald
WaSeaBi: Optimal utilization of seafood side-streams through the design of new holistic process lines

**Extended until Sept 2023**

**HIGHLIGHTS:**
- Technology, infrastructure and logistics
- Efficient and sustainable supply systems for aquatic side-streams
- Nutritional ingredients such as proteins, peptides, savoury ingredients and mineral supplements

**QUICK FACTS:**
- Project duration: 1 May 2019 to 30 April 2023
- Funding: EC contribution € 3.2 million, overall budget € 4 million
- Consortium: 3 research institutes/ universities, 1 industry cluster and 9 companies from Denmark, Sweden, Belgium, France & Spain

Grant agreement No 837726.
WaSeaBi: Optimal utilization of seafood side-streams through the design of new holistic process lines

The context:
The current exploitation of the aquatic resources is hampered by inefficiency as up to 70% end up as low-value products or waste, unsustainable considering the rising population.

WaSeaBi Objective:
Ensure that side-streams from aquaculture, fisheries and aquatic processing industries can be exploited for production of new products and ingredients. By developing storage solutions, sorting technologies and decision tools that will secure an efficient, sustainable supply system for valorization of these raw materials into marketable products.
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**6 different side-streams:**
Representing typical *aquaculture, fisheries and aquatic processing industries* in Europe:

<table>
<thead>
<tr>
<th>Side-stream</th>
<th>Potential use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid side-stream from Cod industry</td>
<td>Food ingredient</td>
</tr>
<tr>
<td>Brine from salted Cod</td>
<td>Protein for reinjection/in-house use</td>
</tr>
<tr>
<td>Solids &amp; process water from herring</td>
<td>Food ingredients</td>
</tr>
<tr>
<td>Salmon solids, mackerel, by-catches</td>
<td>Food &amp; Feed ingredients</td>
</tr>
<tr>
<td><strong>Mussel cooking water</strong></td>
<td>Food ingredients <em>(Savoury compounds)</em></td>
</tr>
<tr>
<td>Mussel shells</td>
<td>Food &amp; Feed ingredients (mineral supplements)</td>
</tr>
</tbody>
</table>

WaSeaBi will take a whole chain perspective to succeed with **high quality production of:**
- Bioactive peptides for nutraceutical, food and feed application
- Protein-based food ingredients
- Savory ingredients and mineral supplements for food and feed
Objectives:
- Optimization of direct concentration of high value molecules
- Estabilization of high molecules extracts
- Evaluate the use of this concentrates for sauvory compounds uses

Some facts about mussel production:
- The European Union is the second largest producer after China (EUFOMA 2019)
- In the north-West of Spain, the annual production of mussels is 200 000 tonnes (35 % of the world) (Bello 2012)
- The industrial thermal treatment of mussels generates between 300 and 400 L/t wastewaters that are continuously disposed into the sea without previous treatment (Prieto 2015)
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Steps for biomolecules recovery:

- Optimization of direct concentration of high value molecules
- Estabilization of high molecules extracts
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Concentration techniques:

Lab vacuum evaporator (Buchi)

Vacuum evaporator (VE)

Mussel cooking water

NF Concentrate

NanoFiltration (NF)

NF Permeate

Mussel cooking water

NF Permeate

NF Concentrate

Diafiltration by NanoFiltration (Dia-NF)

Mussel cooking water

NF Permeate

NF Concentrate

Water

NF Concentrate

Homogenization and heating reactor

Nanofiltration pilot plant
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Analytical and microbiological control:

<table>
<thead>
<tr>
<th>Quantitative Composition</th>
<th>Microbial composition</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>Salmonella spp (Inv/25 g)</td>
<td>Protein content</td>
</tr>
<tr>
<td>Ashes (%)</td>
<td>Listeria monocytogenes (Inv/25 g)</td>
<td>Free Aa</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>Aerobios mesófilos (ufc/g)</td>
<td>Total Aa</td>
</tr>
<tr>
<td>COD (mgO₂/l)</td>
<td>Enterobacterias (ufc/g)</td>
<td>Molecular weight distribution</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>Escherichia coli (ufc/g)</td>
<td></td>
</tr>
</tbody>
</table>

**Protein content**

**Free Aa**

**Total Aa**

**Molecular weight distribution**
**RESULTS**

<table>
<thead>
<tr>
<th></th>
<th>Initial sample</th>
<th>VC Concentrate</th>
<th>NF concentrate</th>
<th>NF permeate</th>
<th>NF – Diaf concentrate</th>
<th>NF – Diaf permeate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashes (%)</td>
<td>2,38</td>
<td>24,48</td>
<td>2,40</td>
<td>2,42</td>
<td>1,20</td>
<td>2,20</td>
</tr>
<tr>
<td>Dry matter (%)</td>
<td>4,09</td>
<td>39,66</td>
<td>9,13</td>
<td>2,47</td>
<td>7,40</td>
<td>2,31</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>1,14</td>
<td>10,98</td>
<td>4,85</td>
<td>0,14</td>
<td>4,68</td>
<td>0,12</td>
</tr>
<tr>
<td>Free Aa (%)</td>
<td>0,33</td>
<td>3,23</td>
<td>1,19</td>
<td>0,12</td>
<td>1,14</td>
<td>0,10</td>
</tr>
<tr>
<td>Chloride (g/l)</td>
<td>14,10</td>
<td><strong>138,18</strong></td>
<td>13,96</td>
<td>14,24</td>
<td><strong>7,12</strong></td>
<td>12,94</td>
</tr>
<tr>
<td>COD (mgO₂/l)</td>
<td>22200</td>
<td>224000</td>
<td>104800</td>
<td>2260</td>
<td>111000</td>
<td>2040</td>
</tr>
</tbody>
</table>
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Optimization of direct concentration of high value molecules

Protein yield for the different concentration techniques tested:

- VC Concentrate: 96%
- NF conc: 85%
- NF perm: 10%
- NF – Dif conc: 82%
- NF – Dif permeate: 13%

Images show the concentrations of NF permeate, NF concentrate, Original sample, and Dia-NF concentrate.
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Optimization of direct concentration of high value molecules

Protein/salt ratio of the different concentration techniques tested
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Optimization of direct concentration of high value molecules

Molecular weight profile of NF and Diafiltration fractions
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Steps for biomolecules recovery:

1. Optimization of direct concentration of high value molecules
2. Estabilization of high molecules extracts
3. Evaluate the use of this concentrates for sauvory compounds uses
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Estabilization of high molecules extracts

<table>
<thead>
<tr>
<th>Optimal Dryer parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T inlet</td>
<td>165 °C</td>
</tr>
<tr>
<td>T outlet</td>
<td>68 °C</td>
</tr>
<tr>
<td>Pump rate</td>
<td>10 %</td>
</tr>
<tr>
<td>Aspirator rate</td>
<td>100 %</td>
</tr>
<tr>
<td>Spray air flow</td>
<td>25 mm</td>
</tr>
</tbody>
</table>

Humedad 6,4 % ± 0,3 %
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Evaluate the use of this concentrates for savoury compounds uses
Different separation techniques had been tested: NF and Diafiltration-NF membrane filtration and vacuum evaporation.

The best concentration system for protein concentration was the vacuum technology, that concentrate proteins almost 10 times.

The problem of vacuum concentration is the high value of salt in the solution, so that, it is necessary to find a technique to remove NaCl.

Both NF techniques yielded lower result in protein recovery, due to the permeation of small molecular weight proteins (≤ 0.1 KDa).

The resulting NF permeate still had an organic load in the final effluent, but reduced enough to be discharged within the regulatory frame.
The best option for biomolecule recovery from mussel cooking waters was the next:

- Filter
- Nanofiltration (NF)
- Diafiltration (DF)
- Spray-dryer

**Conclusions**
THANK YOU

ANY QUESTION?

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