New Strategies for Improving the Sustainability of Breweries: Full Waste Recovery for Aquaculture Feed
Objective: To demonstrate the feasibility of an innovative and sustainable solution for reusing brewer by-products as aqua-feed ingredients through a demonstration trial:

- At semi-industrial scale
- In real operational conditions
- In a real case study
- In a representative EU brewing producing region.

Start date: 01/09/2017

Finish date: 31/12/2020
Scope of the case study:

1. Brewer’s by-products collection
2. Brewer’s by-products collection
3. Brewer’s by-products collection
4. By-products stabilization process
5. Aqua-feed production
6. Fish growth trials
7. Sensory analysis and Demonstration monitoring
1) Pre-industrial optimization of processes for obtaining brewers’ by-products based ingredients
General Objectives

• Assessing the potential of **hydrolysis pre-treatment** to increase the digestibility of by-products
  → By comparing different prototypes with and without hydrolysis.

• Optimization of the **drying process** at semi-industrial scale for obtaining 4 meals prototypes
  1. Dried spent yeast
  2. Hydrolysed and dried spent yeast
  3. Dried spent grain
  4. Hydrolysed and dried spent grain
Optimizing and scaling-up the processing of brewers by-products

1. Dried brewers’ yeast

1. MECHANIC DEWATERING
   - Moisture: 85%

2. BACK MIXING
   - Moisture: 65%

3. FLASH DRYER
   - Moisture: 8%
Optimizing and scaling-up the processing of brewers by-products

2.- Hydrolysed & dried brewers’ yeast

1.- HYDROLYSIS (Moisture 85%)

2.- MECHANIC DEWATERING

3.- BACK MIXING
   Moisture: 30%

4.- FLASH DRYER
   Moisture: 8%

Other applications

Liquid (Moisture: 92 %)

Solid (Moisture: 65%)

Moisture: 92 %

Moisture: 65%

Moisture: 85%

Moisture: 8%
Optimizing and scaling-up the processing of brewers by-products

3.- Dried brewers’ spent grain

1.- BACK MIXING (Moisture : 50%)

2.- FLASH DRYER

Moisture: 85%

Moisture: 8%

Moisture: 8%
Optimizing and scaling-up the processing of brewers by-products

4.- Hydrolysed & dried brewers’ spent grain

1.- HYDROLYSIS (Moisture 90%)

2.- MECHANIC DEWATERING

3.- FLASH DRYER

Moisture: 85%

Solid (Moisture: 55%)

Liquid (Moisture: 92%)

Other applications

Moisture: 8%
2) Valorisation Scheme including all stages of the Value chain
Definition of the Valorisation scheme

• **Valorisation scheme** for the sustainable, efficient and innovative full recovery of BSG and BY as a new raw material for aqua-feed production:

  ➢ **Including all the stages of the Value chain**: 1) Storage in the brewery 2) Collection and transport 3) Processing 4) Aqua-feeds production.

  ➢ **Replicable to any European scenario**

  ➢ **Flexible and adaptable** to different necessities:
    1. Processing in an external plant.
    2. Processing in the breweries: different dimensioning (small, medium or large breweries).

  ➢ Addressing all the **technical and administrative actions** required for each stage.

  ➢ **A Protocol for the appropriate management** of by-products.

  ➢ **A Contingency plan** for the best destination for inappropriate by-products.
Definition of the Valorisation scheme

1. RECEPTION:
   - Contingency plan (brewing industry):
     - Composting
     - Landfill
     - Incineration (sanitary risk)
     - Waste water treatment plant

2. ENZYMATIC HYDROLYSIS
   - By-products traceability control
     - Batch number / Weight / Information...

3. DECANTER
   - HBSY
   - HBSG

4. BACK-MIXING
   - BSG

5. STORAGE
   - Vertical silos
   - Stabilized ingredient

6. DISTRIBUTION
   - Bulk cargo

Quality control:
- Organoleptic control
- Laboratory analysis
- Food security and hygiene control
- APPCC systems
3) Demonstration trial of the Valorisation Scheme
General Objectives

• Demonstrate at a semi-industrial scale, in a representative case study in Spain and in real operation conditions the Valorisation scheme:
Task B3.1 Demonstration Trial at semi-industrial scale

1. 15 tons of BSG and BY has been stored, picked-up and transported to processing plant:
   - During 4 weeks in a radius of about 350 km.

2. 1.5 tons of different 4 ingredients has been produced
   - Dried spent yeast / Hydrolysed and dried spent yeast
   - Dried spent grain / Hydrolysed and dried spent grain

3. 1 ton of experimental diets has been produced for Digestibility trials with fishes
   - Gilthead sea bream & Rainbow trout
   - 2 control & 8 experimental diets (4 prototypes x 2 species); 100 kg /
Task B3.1 Demonstration Trial at semi-industrial scale

4. Digestibility trials with fishes

→ Maximum level of inclusion

- Gilthead sea bream & Rainbow trout
- 25 fish/tank, 3 replicates
- 3 weeks feeding, feces collection and analysis
- C= control

LS= dried yeast, LH= hydrolysed yeast,
BS= dried spent grain, BH= hydrolysed spent grain
Task B3.1 Demonstration Trial at semi-industrial scale

4. Digestibility trials with fishes

- Formula

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Control</th>
<th>D-Yeast 30%</th>
<th>H-Yeast 30%</th>
<th>D-Spent grain 30%</th>
<th>H-Spent grain 30%</th>
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<tr>
<td>Fish meal 70 LT</td>
<td>60,00</td>
<td>40,00</td>
<td>42,00</td>
<td>50,00</td>
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<tr>
<td>Wheat starch</td>
<td>20,95</td>
<td>9,45</td>
<td>7,45</td>
<td>10,00</td>
<td>10,00</td>
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<tr>
<td>Dried Yeast</td>
<td>-</td>
<td>30,00</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Hydrolised yeast</td>
<td></td>
<td></td>
<td>30,00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dried spent grain</td>
<td></td>
<td></td>
<td></td>
<td>20,00</td>
<td></td>
</tr>
<tr>
<td>Hydrolised spent grain</td>
<td></td>
<td></td>
<td></td>
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<td>20,00</td>
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<tr>
<td>Fish oil</td>
<td>18,00</td>
<td>19,50</td>
<td>19,50</td>
<td>16,50</td>
<td>17,00</td>
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<tr>
<td>Vit &amp; Min Premix PV01</td>
<td>1,05</td>
<td>1,05</td>
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<td>1,05</td>
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<tr>
<td>YTRIO</td>
<td>0,02</td>
<td>0,02</td>
<td>0,02</td>
<td>0,02</td>
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</table>

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<thead>
<tr>
<th>Ingredients</th>
<th>Control</th>
<th>D-Yeast 30%</th>
<th>H-Yeast 30%</th>
<th>D-Spent grain 30%</th>
<th>H-Spent grain 30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (DM, g/Kg)</td>
<td>978,30</td>
<td>± 3,09</td>
<td>979,20</td>
<td>± 2,36</td>
<td>976,60</td>
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<tr>
<td>Ash (g/Kg DM)</td>
<td>98,80</td>
<td>± 0,98</td>
<td>83,20</td>
<td>± 0,77</td>
<td>78,70</td>
</tr>
<tr>
<td>Crude protein (g/Kg DM)</td>
<td>419,80</td>
<td>± 3,39</td>
<td>413,30</td>
<td>± 0,16</td>
<td>418,20</td>
</tr>
<tr>
<td>Crude fat (g/Kg DM)</td>
<td>218,42</td>
<td>± 3,29</td>
<td>223,94</td>
<td>± 1,45</td>
<td>234,04</td>
</tr>
<tr>
<td>Carbohydrates (g/Kg DM)</td>
<td>215,10</td>
<td>± 8,42</td>
<td>218,50</td>
<td>± 16,36</td>
<td>197,00</td>
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<tr>
<td>Gross energy (MJ/Kg DM)</td>
<td>18,65</td>
<td>± 0,08</td>
<td>18,89</td>
<td>± 0,19</td>
<td>19,04</td>
</tr>
</tbody>
</table>
Task B3.1 Demonstration Trial at semi-industrial scale

4. Digestibility trials with fishes

- Digestibility of diets – to define the Maximum level of inclusion.

<table>
<thead>
<tr>
<th>Diet</th>
<th>Protein faeces</th>
<th>Protein diet</th>
<th>Av</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TROUT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>318.2 ± 0.56</td>
<td>419.80 ± 3.39</td>
<td>84.12</td>
<td>0.15</td>
</tr>
<tr>
<td>D·Yeast 30%</td>
<td>295.9 ± 1.28</td>
<td>413.30 ± 1.16</td>
<td>78.73</td>
<td>2.11</td>
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<tr>
<td>H·Yeast 30%</td>
<td>314.3 ± 1.46</td>
<td>418.20 ± 2.49</td>
<td>75.99</td>
<td>1.26</td>
</tr>
<tr>
<td>D·Spent grain 30%</td>
<td>247.5 ± 0.06</td>
<td>417.70 ± 3.51</td>
<td>81.96</td>
<td>1.04</td>
</tr>
<tr>
<td>H·Spent grain 30%</td>
<td>224.1 ± 0.21</td>
<td>392.80 ± 0.70</td>
<td>79.69</td>
<td>0.34</td>
</tr>
<tr>
<td><strong>SEA BREAM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>198.1 ± 0.40</td>
<td>419.80 ± 3.39</td>
<td>90.26</td>
<td>0.11</td>
</tr>
<tr>
<td>D·Yeast 30%</td>
<td>262.4 ± 1.59</td>
<td>413.30 ± 1.16</td>
<td>71.76</td>
<td>2.73</td>
</tr>
<tr>
<td>H·Yeast 30%</td>
<td>223.1 ± 2.79</td>
<td>418.20 ± 2.49</td>
<td>75.01</td>
<td>1.27</td>
</tr>
<tr>
<td>D·Spent grain 30%</td>
<td>118.2 ± 3.41</td>
<td>417.70 ± 3.51</td>
<td>84.01</td>
<td>0.54</td>
</tr>
<tr>
<td>H·Spent grain 30%</td>
<td>87.8 ± 0.90</td>
<td>392.80 ± 0.70</td>
<td>85.22</td>
<td>0.31</td>
</tr>
</tbody>
</table>
Conclusions

1. The Valorisation Scheme has been defined and validated along the entire value chain for the safe reuse of brewers’ by-products as an ingredient for aquaculture: 
   *Flexible and adaptable to different necessities*

2. The production of the 4 prototypes of ingredients: spent yeast and grain, hydrolysed and non-hydrolysed, has been technically validated at semi-industrial scale: *Innovative and energy efficient process*.

3. The results of the Digestibility tests of the diets has been positive: *Ingredients suitable for aquaculture.*
Next steps

1. **2nd Nutritional efficiency** trials

   They will provide the necessary information to adjust the *Optimum level of inclusion of the ingredients in aquaculture feeds*.

2. A **Sensorial analysis** of the produced fishes

   It will validate the *quality of fishes*.

3. A **techno-economic and environmental study** & a **Transferability plan**

   *Business model* which fulfils all requirements of brewer and aquaculture sector.
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Thank you!

Any question?

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