

Valorisation of brewers' yeast and spent grain as second-generation feedstuff for aquaculture feed

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EU is the 2nd largest beer producer in the world (383 million HI in 2014), ahead of USA, Brazil and Russia, with more than 6,500 breweries. Beer production has a double environmental impact: 1) beer production and 2) wastes management. The largest volume are brewers' spent grains (BSG) (80 % of total solid by-products), followed by brewers' yeast (BY) (10 %). So, given EU beer production in 2014, more than 6 million tons of BSG (15-20 kg of BSG per 1 HI of beer) and 0.8 million tons of BY (1.5-3 kg of BY per 1 HI of beer) were generated.

BY is mixed with wastewater and discharged for its treatment, while 70 % of BSG is used in fresh for feed, 10 % for biogas production and 20 % is landfilled. This implies the loss of a valuable product. The use of 70 % of BSG as a direct supply for animal feed without any treatment depends on many factors which can limit significantly their feasibility and, in many cases, can make it unsustainable. The high moisture content together with its high microbial load and the high temperature at which they are generated makes their useful life not more than 48 hours. The biogas production involves 10 % of BSG produced in Europe. Furthermore, although the use of these by-products for human consumption or even for pharmaceutical and cosmetic purposes could be a valuable option, a solution able to cope with larger volumes is needed. Finally, aqua-feed production alternative involves the higher protein conversion efficiency, with a 30 %, above chicken with a 25 %, pork 15 % or beef 5 %.

Due to their high BOD levels and water content, an inadequate management can produce remarkable impacts on the environment. Only regarding greenhouse gases emission, managing BSG in a landfill has an impact of around 513 kg CO₂ equivalent by ton of waste disposed, while the treatment of BY together with wastewater is around 83 kg CO₂ equivalent by ton of waste treated. It is estimated that, with the proposed solution, the greenhouse gases emissions which are potentially avoidable are about 615.6 million kg of CO₂ equivalent, in case of BSG, and 66.4 million kg CO₂ equivalent, in case of BY.

Aqua-feeds are specially formulated to contain all the essential nutrients that farmed fishes need to keep healthy and to maintain the human health benefits of seafood consumption. Currently, they are highly dependent on fish meal (FM) and fish oils (FO). Of the global production of FM (about 4.8 million tonnes), approximately 65% is utilized in aquaculture production, while of the global production of FO (about 1 million tonnes), approximately 83% goes to aquaculture production, Tacon *et al.* (2008).

Within this framework, alternative ingredients which successfully replace these marine components with non-traditional sources are required to result in sustainable and economical feeds. Reducing aquaculture's dependence on marine resources in the future will depend on improving feed efficiencies and substituting away from fishmeal and fish oil. Therefore, brewers' by-products stand as a potential alternative for replacing fish meal in aquaculture feed, due to their availability in Europe, their nutritional characteristics and the preliminary results obtained in the previous project carried out (Aquadiet project). Their availability will also contribute to reduce the environmental impact related to fish meal based aqua-feed.

Samuel-Fitwi *et al.* (2013) have demonstrated that replacing FM by other alternative ingredients, such as soybean or rapeseed, involves less environmental impact per tonne of aqua-feed in both Acidification potential (AP); Global Warming potential (GWP); Eutrophication potential (EP) or Land competition (LC) than fish meal based standard aqua-feed. Thus, in case of the GWP, the fish meal standard trout feed has an impact of 1,797 kg CO₂ equivalent per ton while the soybean meal and rapeseed meal based aqua-feeds has 1,019.65 and 1,037.13 kg CO₂, respectively. The maximum level of substitution of FM and FO depends on the species. For example, in the case of sea bream, it can reach up to 100% FM and 70% FO replacement followed by a refeeding period to recover the levels of omega 3 fatty acids in the fillet.

The Brewery project (LIFE16 ENV/ES/000160), funded by the European Commission Life Program demonstrates the feasibility of the utilisation of BY and BSG in Senegalese sole, Sea bream and Trout feeding in the north-east region of Spain by carrying out five actions:

1. Pre-Industrial optimization of processes for obtaining brewers' by-products based meal & aquafeed prototypes: An optimized drying process at semi-industrial scale will be developed obtaining 2 meal prototypes. Experimental aqua-feed diets including developed 2 meals will be optimized till maximum level of inclusion.
2. Design of a valorisation scheme for brewers' by-products including all stages of the value chain: The valorisation scheme will address the technical and administrative actions for each stage. It will be contrasted with Stakeholders.
3. Demonstration trial of the valorisation scheme applied to the case study: north-east region of Spain. A demonstration trial at a semi-industrial scale and in real operational conditions will be carried out. By-products will be taken from three of the most important breweries of Spain. They will be stabilized by an optimized drying process. Fish growth trial with developed aqua-feed will be carried out. Finally, the sensory quality of produced fish will be assessed.
4. Feasibility assessment of the implementation of the valorisation scheme in an industrial reference scenario: The valorisation scheme will be assessed from the technical, economic, social and environmental points of view, as well as the eco-design of the valorisation plant at full scale.
5. Replicability and transferability of the valorisation scheme at European Level: The valorisation scheme will be replicated and transferred to EU. A comprehensive analysis of the replicability to 2 European areas will be carried out. A replicability and transferability plan will be performed in each of them.

The project aims to increase the EU aquaculture sustainability by providing 2 sustainable raw materials from BSG and BY by-products for aquaculture feed, which will decrease the dependence of fish meal production. The specific expected results are:

- Brewers' by-products (spent grain and yeast) valorisation scheme for producing 2 new raw materials for aqua-feed, validated by stakeholders and scaled-up in a demonstration trial.
- 3 new sustainable aqua-feed diets containing the 2 new raw materials from brewers' spent grain and yeast meals, successfully tested in Senegalese sole, Sea bream and Trout by fish growth trials.
- An integrated basic Eco-Design of a model recovery plant, replicable to any region of Europe, which allows the transfer of the valorisation scheme implemented in the case study (Spain) to other European regions.
- An Exploitation plan of the valorisation scheme that recycles at least 95 % of the brewer by-products in the case study region (Spain) in two years after the end of the project.
- Replication and Transference of the valorisation scheme to 2 EU regions for recovering at least 85 % of their brewer by-products in three years after the end of the project.

The Brewery project contributes to:

- The sustainability of the aquaculture in the future by reducing 25 % of the environmental impact associated with aqua-feed production of 3 targeted species by replacing, in two years after the end of the project, at least 15 % of the fish meal used currently with a new raw material from brewer by-products.
- The awareness of the society toward sustainability by interacting with more than 5,000 people.
- Up to 50 direct employments in the by-product valorisation sector in three years after the end of the project.

References

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