BONUS OPTIMUS: WP6

Deliverable Report (D6.1)

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Others participating: Svend- Erik Thomsen (Grainas, former Grainwood)

Objective: Undersized blue mussels grown for mitigation purpose (WP 1-5) may have a potential as use in feeds for aquaculture as mussels contain high protein levels with an optimal amino acid composition and a good fatty acid composition.

Description WP 6- from the DOW:

Deliverables	**Month**
D6.1 Development of new cost-efficient technique for processing mussel meal.	14 (delivered month 36)

Introduction:

Mussel meat has nutritional properties of protein, amino acids and essential fatty acids, that are similar to those of fish meal and has proved a good substitute for fish meal in feeds for several species of fish (Berge & Austreng, 1989; Kikuchi and Sakaguchi, 1996, Kikuchi and Furuta 2009; Larsen 2014). In addition, mussel meal may provide additional properties in terms of valuable pigments and attractants (Berge & Austreng, 1989; Florian et al., 2014).

Several challenges, however exist before mitigation blue mussel production can be a competitive and sustainable resource for fish feed. Production cost is an important factor determining the potential as a future nutrient resource in fish feeds. Although production of mitigation mussels is cheaper than production of uniform large sized mussels for human consumption, due to less labour (no grading, socking), production costs still comprise investment, growing, harvest, transport as well as processing.
Mussels produced for mitigation purpose (as compared with mussels for human consumption) are of a much more varying size (Fig. 1.), from very small to large mussels – resulting in a higher proportion of fragile small mussels, which may have implications during harvest, transport and processing, and may affect storage time before start of qualitative deterioration. In general mussles produced for mitigation purpose have less biofouling than mussles produced for consumption. However, biofouling (a.o. sponges and barnacles) may, - if not removed, influence on the nutritional composition and quality of the final product, and limit its ability to be used as a macronutrient for fish feed.

By traditional processing of mussels used for consumption (Vilsund Blue, Nykøbing Mors, DK), the dredged mussels are subsequent to harvest de-clumped and unwanted organisms (barnacles, sea stars, byssus etc.) are removed. The mussels are graded and larger mussels (> 4.5 cm) are kept in large cleaning bassins with flow of fjord water to remove sand, algae etc. During the following processing mussels are cooked, deshelled and sorted, and used for conserves or freezed. The juice from cooking may be upconcentrated and converted into mussel meal by spray drying techniques.

Fig 1. Mitigation mussels for harvest

Objectives WP 6.1

The main objective was to investigate possible cost-effective methods of processing mitigation mussels into meals for fish feeds.

As fish opposite to poultry have little use of the calcium carbonate rich shell fraction and high dietary ash contents are normally unwanted in an energy dense modern extruded fish feeds, - the focus in WP6.1. was to avoid shell remains in the meal product, but at the same time to keep low costs in processing and manufacturing of a mussel meal.

Grainwood A/S (i.e. today: Grainas A/S) with more than 30 years of experience within developing, project engineering, sales and installation of machinery plants for the grain; feed; bio- waste- and recycling industry was the commercial responsible partner for testing various methodologies at their production test site in Nykøbing Mors, DK.

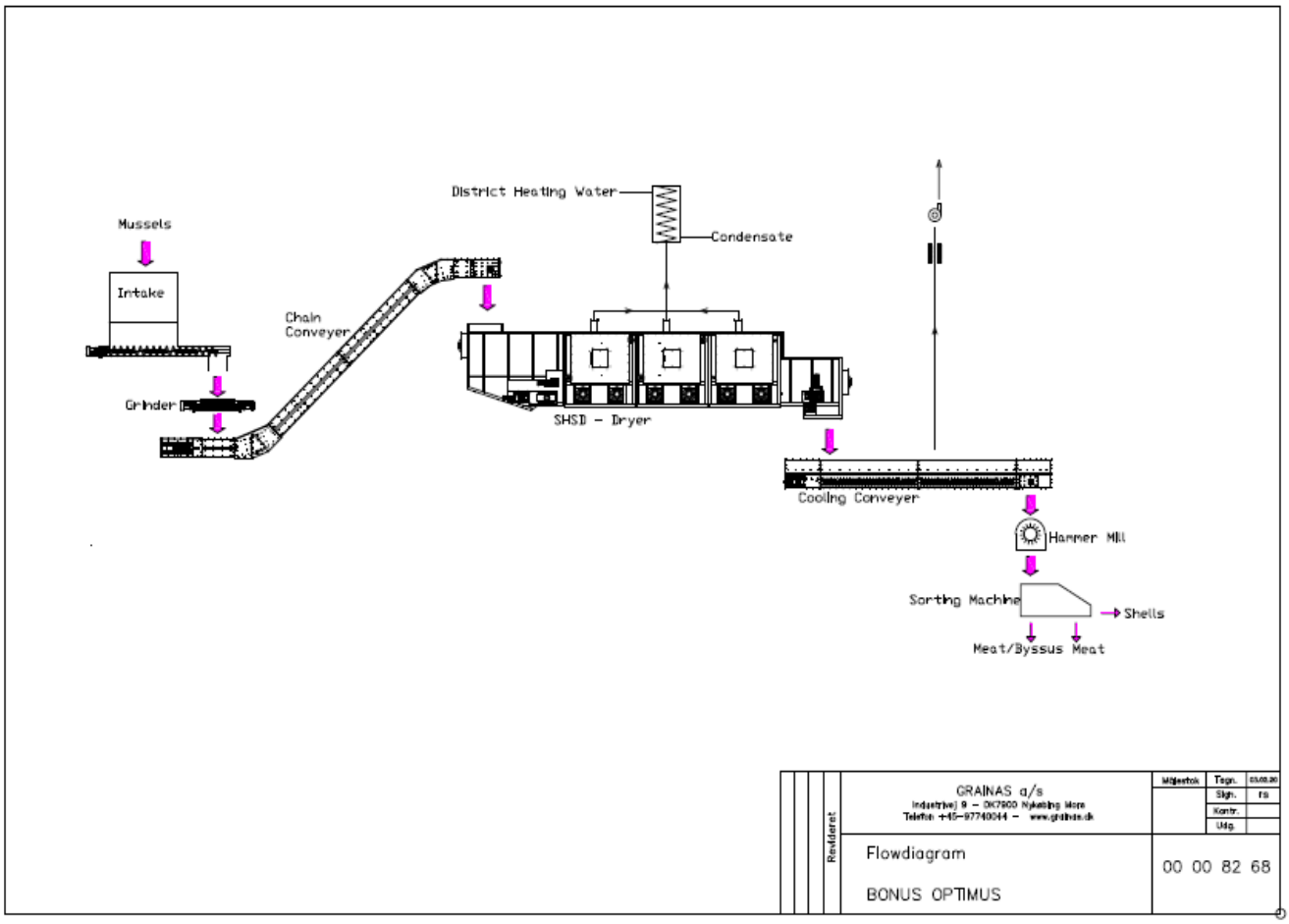
6.1.0 Applied methodologies at Grainas A/S

The tests were performed at a new developed Super heat Steam Dryer System (SHSD). Here the mussel biomass is dried at 100° C until mussels open.

The procedure followed was:

- Harvested mitigation mussels (5 t.) were transported by a framed chain- conveyor to a container placed above a dryer (Fig.2).
- The mussels were then let by feed rollers and screw conveyors to a drying conveyor belt, at which the steam drying process was started by addition of overheated dry steam at 110-130° C.
- Soon hereafter the mussels opened, and the drying process started for which the evaporated overheated steam from the mussels (evaporated water content) were circulated through radiators (heated with hot oils). The steam was then led to a pipe exchanger by a slight overpressure and the steam condensed (to water) within a piping system and potentially recovered as for use as district heating (water temp.90°C.)
- In the initial tests, mussels were kept for 22 min. in this steam drying system before they were then transported out of the dryer to be cooled down by aeration. The mussels at this stage contained app. 10 % water.
- Several tests were carried out with the above methodology (Fig.2) at various temperature regimes and by different retention times in the steam dryer to find an optimal procedure to separate mussels form the shells in a gentle way.

Fig. 2. Processing steps at the Grainas Industrial Plant



Results

- All tests showed that during processing the mussel meat burned up to the shells and a further subsequent separation of shells and mussel meat was not possible.
- With the methodology tested, it was possible to isolate and separate the dried byssus threads from the mussels.
- The drying process involved circulation of evaporated steam and heat - and it was possible to reuse 85% of the energy in the drying process for use as process heating or condensed to water of 90° C (- a potential use for district heating).

6.1.1 Separation of steam dried mussels from shells.

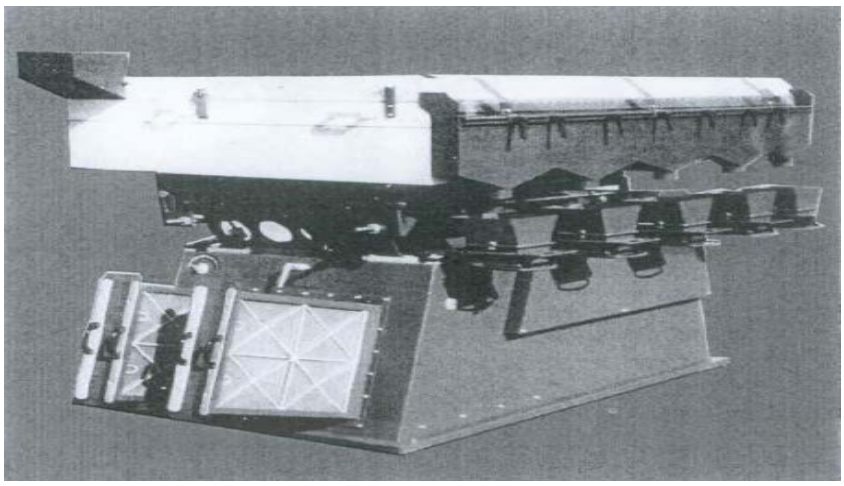
Based on the results with described methodology (6.1.0.) and the limited success of separating meat from shells during the drying process, Grainas explored the possibilities to subsequently separate shells from dried mussels after the drying process.

Thus, dried mussels (90% DM) were crushed in a mill having various sieves of different pore sizes (2-10 mm) and the product obtained is illustrated in Fig.3.

Fig. 3 Upper picture: Grinder and divider unit before separation of mussels, lower picture: Dried and grinded whole mussels

Separation was carried out by ”winnowing” used normally for grains and husks (Fig.4), an efficient method to separate particles by density. The results were here evaluated based on the effect of the separation of meat and shells and other fractions.

Fig. 4 Winnowing unit used for separation



This method showed that, it was partly possible to separate mussel meat from shells, based on density/weight. However, a relatively large part of shell particles still remained in the final product (Fig. 5), probably from mussels where meat did not separate from shells.

The present product was not optimal as usage for fish feed ingredient as due to a too high shell fraction (but the product may have potential for poultry feed)

Fig. 5 Product after winnowing (left), Light microscopy photo (right)

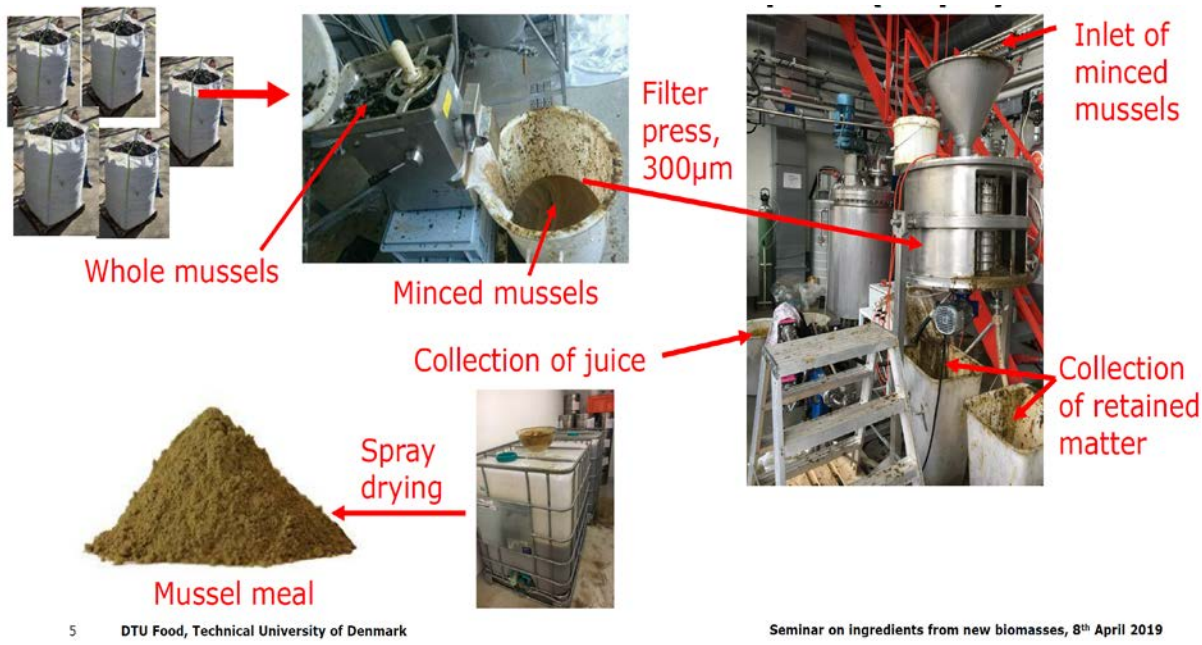
Grainas A/S had no further ideas or methodologies to optimize the separation process and to ensure a product quality as for use as fish feed ingredient.

6.2.0. Other processing methods

Further experiments and processing was thus carried out with DTU Food (MuMiPRO project).
As separation of mitigation mussel meat and shell fraction was not successful either with the harvested biomass or with the dried biomass, a simpler approach was considered, which involved grinding of the whole biomass to separate the organic tissue part from the inorganic part.

Four tons of mitigation mussels obtained from the Limfjord were shipped to DTU Food. The unprocessed biomass was then crushed in a food grinder; juiced; centrifuged and spray dried (Fig. 6) at two temperatures, respectively 75°C and 90°C. Meal products were incorporated at various inclusion levels into fish feed and tested on juvenile rainbow trout in various trials (please refer to BONUS-OPTIMUS Deliverable 6.2-6.5).

Fig. 6 Processing procedure at DTU Food (Foto: Nina Gringer, DTU Food)



Results showed, that it was possible to produce a mussel meal product by this methodology, but that the product also had a relatively high content of ash (shell remains) despite sieving of the retained grinded juice.
It is probably possible to reduce the ash content further by optimizing the sieving procedure and initial declumping and cleaning of the harvested biomass for unwanted biofouling organisms, which likely may enhance product quality. Additional costs will be expected by a further pre-processing. The juice dewatering process and spray drying are processes, that need to be optimized to be cost efficient.

Conclusions:

- Several methodologies were tested to find optimal solution in processing of mitigation mussels to mussel meal applicable as fish feed ingredient.
- Grainas A/S was not able to prove a successful cost-effective method of separation of shells from mussel tissue, neither with the fresh – or dried biomass.
- Grainas A/S developed an energy saving method for drying of deshelled mussels for which energy can be re-used in the process or used as external district heating.
- DTU Food used a simple grinding approach to separate juice (and organic nutrients) from inorganic shells. The methodology needs further optimization before applicable and cost efficient - i.e. better separation (sieving) of small fraction shell parts and lower costs in dewatering and spray drying for obtaining a meal.

Postscript:

During the OPTIMUS project DTU Aqua has been in close contact with a commercial company (Blue Biomass A/S, DK (Hedeselskabet), which was established in 2016 and partners have exchanged ideas regarding processing of mussels produced for mitigation purposes. The concept of Blue Biomass A/S is to produce, process and sell commercial marine blue biomass (blue mussels) and to make a commercially viable production. The company produce both conventional mussel meal - and mussel meal of mitigation mussels. The mitigation mussels are dried and air – sieved (- a similar method of winnowing, that has been demonstrated in the OPTIMUS project)

At present DTU Aqua is involved in a project with TripleNine Fish Protein A/S, DK to investigate various inclusion levels of this mussel meal product (Blue Biomass A/S) into a traditional ish meal and tests these products in fish feeds for salmonids. Preliminary results from studies on salmon in Norway may show promising higher feed intake at relatively low ratio mussel meal:fish meal inclusion levels.

The first study at DTU Aqua is planned to start primo April 2020.