***Summary Findings for the Irish Seafood Industry: Feasibility Study of Dehydration Technology for Fish Processing Residuals and Unwanted & Unavoidable Catch Landed into Ireland***

## 1. Introduction

EU law now requires that all fish caught at sea, including undersize, unintended and over quote fish, must be landed at ports throughout Ireland so they can be accounted for in the sustainable management of Europe's fisheries and used in the setting of annual fishing quotas.

The purpose of the report is to evaluate the feasibility of using on-site dehydration technology to manage fish processing residuals and unwanted & unavoidable catch (UUC) in Ireland and to see if the use of this equipment can create value from these materials.

Therefore, the report contains the following:

- An estimate the types and quantities of fish processing waste and UUC in Ireland
- A description of on-site biowaste management systems for handing such materials: composting, anaerobic digestion, biodigestion and drying/dehydration
- An inventory and description of commercially available drying/dehydration equipment
- A standard operating procedure for one type of dehydration equipment
- A summary of research gaps for the operation and management of these systems within an Irish fisheries context
- A pilot project plan to test the use of the equipment at a seafood processor in Ireland
- A description of pilot project activities and results from using a small dehydrator in the Port of Howth.
- A summary of nutritional and nutrient testing results of the solid output product and BOD/COD testing of the condensate from the pilot project equipment
- A description of the potential uses and value for the solid product produced by the dehydration equipment
- A preliminary economic analysis for on-site application of the technology
- A summary of conclusions and recommendations from the research and pilot project

## 2. Dehydration & Drying Systems

*Description & Defining Characteristics:*

Dehydrators use a mechanical- thermal approach to dry food materials with a 70-90% water content to 1-20% moisture. These systems are mostly operated on a batch basis although some work like a continuous system where materials are fed into one end and are extracted from the other end. Most systems consist of an enclosed trough with a rotating mixing device to move materials from one end to the other. The semi circular trough at the bottom is often fitted with a thermal heating device or blanket on the outside to heat materials up inside the chamber to 80-160+ degrees C. The mechanical mixing and heating of the trough dries materials to a powder like substance within 10-24 hours depending on the feedstock used, the size of the unit and type of equipment utilized. During this process, water vapour is produced within the processing chamber. Some systems simply filter the odour out of the air using a carbon filter and vent it out into the surroundings while others condense the moisture laden air into a liquid that requires disposal into the sewer. Although the liquid can be clear or opaque in colour, it does have some nutrients with a low to moderate level of BOD or biological oxygen demand. A few systems use a biological agent to help break down the cell walls of the food waste to facilitate the release of water.

*Outputs from the Process:*

The main output of the process is a sterile organic biomass product that contains 1-20% moisture. A by-product of the system, in some cases, is a condensate liquid that results from reconstituting the water vapour captured from the enclosed processing chamber.

*Advantages & Disadvantages:*

Advantages include:

- can handle pure fish processing waste or shredded whole fish without the addition of water, bulking materials or other balancing feedstocks
- 80-90% reduction of input in volume and weight; 250 pounds of food waste into 25-50 pounds of sterile organic biomass and 25-28 gallons of water (200-224 pounds)
- small footprint, doesn't require a lot of space, but a little more than biodigesters and a lot less than biogas or composting systems
- can be easily installed indoors (smaller systems) or outdoors within an enclosed building (larger systems)
- totally enclosed to minimize odours and exclude pests

Disadvantages include:

- mostly batch systems which may require stockpiling or storing of materials between batches for processing

- can use a lot of electricity (smaller systems) or energy (natural gas or electricity for larger systems) for drying
- solids that come out are not stable; when used as a soil amendment on its own without further curing, it may encourage fungal growth, create odours and/or attract pests
- in some systems, water vapor is reconstituted into condensate that needs disposal

## 3. Operation of Pilot Project Equipment

A Gobi G100 from Tidy Planet in the UK was shipped over to Howth and delivered to Doran's in late June of 2019 for eight weeks. The capacity of this model is 100 kg per day, one of the smallest provided by the vendor, allowing two batches of 50kg processed within 24 hours using a 8-10 hour cycle time for each batch. The equipment was placed into the fish processing area of the business to facilitate the operation of the equipment and the weighing of input and output materials. An electrician was required to extend a three phase power supply to the unit providing at least 16amps of power. An electric meter was installed between the unit and the power supply to measure kilowatt hours used by the equipment for each batch. Finally a plastic tub was placed on the floor to collect condensate from the machine so the liquid from each batch could be measured for mass balance purposes. A picture of the unit set up and ready to go is shown below.


As can be seen in the picture above on the left side, a hose from the back of the unit was placed into a plastic container to collect condensate. The electric meter used to measure kilowatt hours is hanging on the back wall and is on the left hand side of the machine. The process control panel is located on the upper left hand side of the front panel and is above the Tidy Planet sticker. This allows the operator to start and stop the equipment, control the cycle time, set processing temperatures and trigger unloading functions. Input materials are fed into the top stainless steel hatch while output solids are discharged from the shoot in the middle of the front panel. The small door on the right side of the front panel above the Gobi sticker provides access to one of the filters which required daily cleaning with water.

16 official batches of haddock and whiting were run through the machine as whole fish, fish processing residuals and a combination of both. Unofficial trials included batches of salmon processing residuals, Dublin Bay prawn processing residuals, a combination of salmon and prawn processing residuals, processing residuals from a mix of fish and a combination of restaurant food waste and fish processing residuals.

The processing steps used to operate the equipment are shown below:

1. Weigh input materials on an electronic digital scale in 40kg batches.

2. Load input materials into the machine through the hatch on top of the unit.

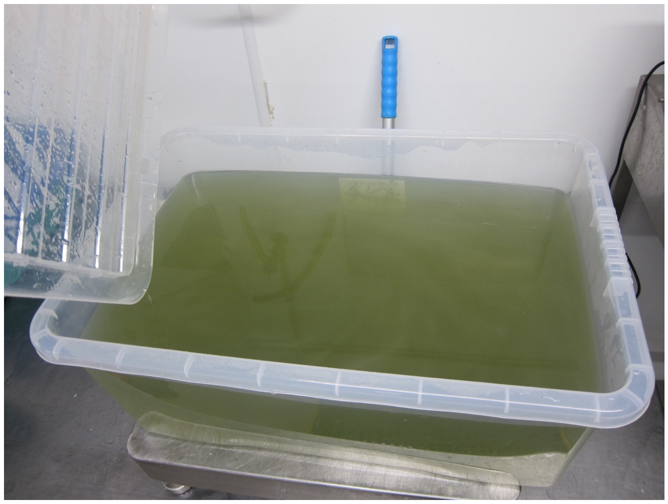
3. Close loading hatch and turn machine on. Cycle time was set for 10 hours. Temperature set point was placed at 165°C. While machine is in operating mode, the stainless steel augers within the processing trough, as seen in the picture to the right, mixes and chops input materials. The stainless steel processing trough sits inside a larger trough which is filled with oil that is heated with electrically powered heating elements. If the temperature probe within the processing trough senses temperatures of the materials within it exceeding 165°C, all of the moisture has been driven out of the materials, the batch is finished and the machine shuts off. Otherwise the timer automatically turns the machine off after 10 hours.

4. After materials within the processing trough have had a chance to cool down, the solid materials are discharged through the shoot in the middle of the front panel. The door to the discharge shoot is opened, a bucket is placed underneath and the discharge button is pushed on the process control panel. This reverses the augers within the processing trough so that the dried materials can be pushed out of the machine and into a plastic collection bucket as shown to the right.

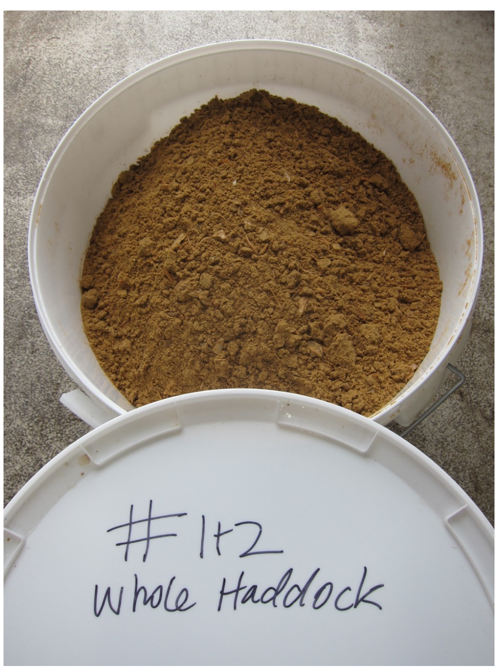
5. After discharge of the dried product, the trough and filters were cleaned so the machine could be ready for the next batch.

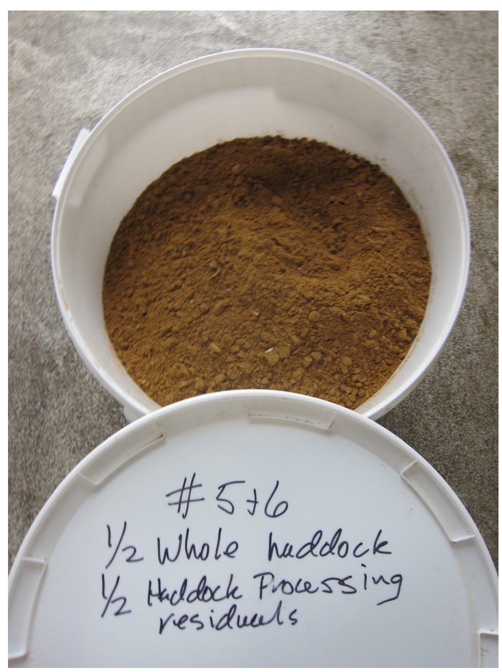
6. The bucket of dried product and the container of condensate were then weighed and recorded. The solids were stored in sealed buckets and the condensate was emptied into a sanitary sewer drain. Once the solids were placed into a storage bucket, a 200 gram sample of the product was placed into a labeled zip lock plastic bag for laboratory testing. Lastly, the electric meter was read and a note of kilowatt hours used was recorded for each batch.

The dehydration machine trialled produced two output products: a solid material and a liquid condensate. The condensate was not a clear liquid but a tan brownish or green coloured liquid as shown below.



A sample of condensate was sent off for laboratory testing for biological oxygen demand (BOD) and chemical oxygen demand (COD). The solid material produced by the machine was a dry course powdery material medium brown to dark brown in colour. All batches contained small bone fragments. All batches except two produced a dry powder like material. The two batches of whiting processing residuals produced a more solid like product resembling animal feces. One batch produced small pellet like output like rabbit droppings while the other trial produced larger balls resembling dog poop. The solid output product from the salmon processing residuals resembled an oily sludge with long fish bones in it. This is the result of the naturally high oil content of salmon. As discussed above, when a portion of salmon processing residuals was mixed with prawn processing residuals at a ratio of 1 to 8, the final solid product was not too dry and not too oily and resembled the dry course materials produced by most batches of the official trial. What follows are some photos of the final solid product.




Shown above are the solid outputs from haddock processing residuals to the left and from whiting processing residuals to the right, in chunky balls.

What can be observed is that the output from whole fish is lighter in colour than the output from fish processing residuals. This would most likely be explained by the fact that fish guts and the leftovers from processing contain blood. In addition, it seems that the whiting processing residuals have a higher oil content than the haddock processing residuals which is the reason why the final whiting processing residual material consists of small to large ball shaped output.

## 4. Conclusions

The main take aways from this project and report include:

a. It is estimated that there could be as much as 67,437 tonnes per year of UUC whole fish generated by fishermen when the EU's landing obligation is fully met for Ireland.

b. It is estimated that there could be around 77,416 tonnes per year of fish processing residuals generated by aquaculture operations (7,416 tonnes per year) and from 163 fish processing facilities within Ireland (70,000 tonnes per year).

c. Outlets for whole fish and fish processing residuals consist of production of fish meal in Killybegs, production of fish oil and proteins and use as an ingredient in pet food.

d. Outlets for fish processing residuals only include bait for fishing, compost production and land spreading of fish processing sludges. Generally low value markets.

e. There is a huge need for creating value-added options for the processing of both UUC whole fish and fish processing residuals within Ireland. The fish meal plant at Killybegs is operating a bit under capacity, but would be too far and thus expensive for a lot of fisherman or fish processing facilities to transport materials to Donegal.

f. Based on internet research and follow up e-mail and phone conversations, there are 9 potential vendors of on-site dehydration equipment that could sell equipment to end users in Ireland. Some have technology that works well and in other cases some have machinery that is not proven or reliable. Equipment ranges in size from 25 kilograms per day to 50 tonnes per day.

g. Capital cost for the dehydration systems range from €20,540 for a 100kg/day system to €2 million for a 50 tonne/day system. For around a tonne per day capacity, systems cost between €77,160 - €136,527.

h. Energy costs seem to be the highest operational cost of the equipment. According to vendor claims, energy costs are between €11-80/tonne of input processed. Using an older smaller piece of equipment for the pilot project, energy consumption was measured by an in-line meter and averaged 1 kilowatt hour for every kilogram of fresh materials processed. At 16 cents a kilowatt hour, energy costs were close to €160/tonne of input materials.

i. The pilot project demonstrated that the dehydration equipment obtained from Tidy Planet in the UK works well to reduce the weight and volume of whole fish and fish processing residuals by 75-80%. With a very low moisture content, the solid output product is stable and has a long shelf life.

j. As a potential feed, laboratory test results indicated that the solid output product contains 46-84% protein depending on the contents of the material processed (whole fish, processing residuals or a mix of both). As a potential fertiliser, laboratory test results indicated the solid output material contained 11% Nitrogen, 2.5% Phosphorus and 1% Potassium.

k. In a conversation with the CEO of the Organic Trust, Ltd., the solid output product from the dehydration equipment can “in principal” be certified as an organic fertiliser or an ingredient in an organic fertiliser blend.

l. The solid output product from the pilot project was trialled as a crab and lobster bait and it was neither wildly successful nor a complete failure. Although the fisherman conducting the trial seems to think that the bait made from the pilot project was as good as traditional bait of hake heads and skeletons, log sheets indicated that the traditional bait worked a little bit better.

m. The solid output product may be used as an ingredient in fish food, cannot be used as a feed for livestock due to Animal By-Product regulations, might be a potential ingredient in weaner (young pigs) feed and poultry feed.

n. The nutrient value as an organic fertiliser is estimated to be €185 per tonne (€1 per kg of N, €2 per kg of P and €1 per kg of K). Use of the solid output product could be blended with other materials such as poultry manure to produce organic fertiliser pellets that could be easily spread onto farm land. As there is a glut of material such as manure, slurry and digestate from biogas plants looking for land to be spread on, there is little demand for alternative products. A producer of organic fertilisers indicated that the wholesale price for the material would be €40-60/tonne, not enough to cover energy costs for most equipment.

o. The best market identified for the material would be as an organic fertilizer for wholesale or retail sale to horticultural growers, landscapers and home gardeners. Wholesale pricing in this market is estimated to be between €125-2,333 and retail pricing in the €499-9,333 range. Comparing it to a similar organic fertiliser in nutrient value to a product made by Vergranno, Ltd. (12:1:0.5 NPK), the retail value would be between €1,105 and €1,300/tonne. On a wholesale basis, this could be €600-700/tonne.

p. Preliminary economic analysis for the pilot project shows that the feasibility of the project would be very challenging and not cost-effective because the fish processing facility is currently getting rid of its processing residuals for free to mink farms and the capital cost and high energy use of the smaller unit requires selling the final output product at a very high price (€1,670.76 and €2,088.45/tonne for the final output product).

q. The equipment becomes more feasible if a fisherman or fish processing operation is required to recycle the material at a biogas plant or composting facility with costs between €60-160/tonne, including transport, the energy cost of the dehydration equipment can be cut in half from the smaller older system used by the pilot project, and that the solid output product can be sold into feed, bait or fertiliser markets. Savings from high disposal costs alone could make these systems cost-effective.

## 5. Recommendations

Several recommendations can be made from the research and pilot project conducted in this study, including:

a. Conduct an economic feasibility of a larger scale facility in Howth to utilize materials from businesses within County Fingal. Specific items of research and feasibility assessment include:

- Quantifying the potential supply of fish processing residuals and UUC materials from the various fishermen and fish related businesses within Howth and County Fingal
- Sizing the equipment and facility to handle this volume of materials
- Developing a conceptual design for a facility including space required, infrastructure elements and equipment needed
- Estimating capital costs of a site, building, equipment and site improvements required
- Estimating the operating costs of the facility
- Testing the market by meeting with potential buyers
- Estimating potential revenues from the organic fertiliser, fish and poultry feed and bait markets
- Identifying potential grants available for the project
- Running a spreadsheet model to determine economic feasibility of the facility to include capital budget, operational budget and revenue forecasts to produce five year income statement and financial summary.

b. Survey existing fish processing facilities within Ireland to more accurately quantify the amount of fish processing residuals produced by the seafood processing sector.

c. Begin to quantify the amount of UUC being brought to shore by fishermen so that a more accurate estimate of materials can be made by extrapolating real data to the fishing fleet in Ireland.

d. Continue to explore more potential uses of the solid output product so that a more accurate value can be placed on the material, such as use as a fishing bait, use in dried cat food, use in production of fish and poultry feed and use as an organic fertiliser.

e. Conduct growth trials with the solid output product on locally grown horticultural products (tomatoes, broccoli, cabbage, carrots, potatoes, onions, etc.) in conjunction with Teagasc to determine its effectiveness as an organic fertiliser. Develop several organic fertliser blends to include the solid output product as one ingredient in a more balanced organic fertiliser and conduct growth trials on those.

f. Experiment with fish feed, poultry feed and fish bait recipes and products. Conduct feed trials in aquaculture and/or poultry operations as well as more bait applications for different species such as whelk.

g. Develop a brand concept as well as a marketing and pricing strategy for various feed, bait and fertiliser products.

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