Institution: Heriot-Watt University

Unit of Assessment: UoA8 Chemistry

Title of case study:
Horizon Proteins: Circular economy innovation from whisky by-product to fish feedstock

Period when the underpinning research was undertaken: 2011 - 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Nik Willoughby Dawn Maskell Jane White	Professor of Bioprocessing Associate Professor, Director of ICBD Assistant Professor	1/04/06 – Present 1/10/12 – Present 1/03/11 – Present

Period when the claimed impact occurred: November 2014 – December 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

Research at Heriot-Watt University has developed, patented and demonstrated a way to extract the protein from the pot ale by-product residue of malt whisky production and transform it into feed-stocks for aquaculture. The impacts arising include:

(A) Creation of a spinout company Horizon Proteins Ltd (HP) in 2014, to exploit the new bio-technology, supporting rural circular economies and showcased by the UK government at Milan Expo 2015;

(B) Investment of circa £5 million (2018) towards exploiting research and the planning and construction start of HP's first manufacturing plant, creating skilled jobs for the rural economy (the new plant has been designed and engineered to treat 200,000 tonnes of pot ale per annum).

(C) Conversion of whisky by-product residue to new feed-stocks for aquaculture resulted in a 600% increase in the asset value of the by-product residue;

(D) Strategic partnership with EWOS Cargill for business-to-business supply chain of HP feedstock for the salmon producer market;

(E) Environmental benefits in reduction of the chemical oxygen demand to treat the waste and using local sourcing for aquaculture feedstock, rather than using imports.

2. Underpinning research

Every year, the Scottish whisky industry brings in around £5 billion in export revenue (2019) but produces over three billion litres of pot ale, a residual by-product that is very challenging to dispose of. For decades, the distilling industry has been striving to develop synergy through increasing both economic and environmental sustainability. The salmon aquaculture industry, which supports 2,300 jobs directly, requires secure supplies of affordable, sustainable, high quality protein feed ingredients to realise annual salmon export revenues of around GBP800,000.000.

Driven by the challenges both diverse industry sectors faced, HWU researchers, led by Prof Willoughby, started in 2011 to investigate the potential of converting the residual by-product from the whisky industry into a high quality protein feed that could serve the aquaculture sector (e.g. the salmon industry). This would support a strategically important rural economy sector.

The research was multi-inter-disciplinary, involving Engineering & Physical Sciences, Biological Chemistry, Biophysics and Bioengineering, Mechanical, Process and Energy Engineering.

The research challenges for the needs of both whisky and aquaculture industries were paramount in terms of the early underpinning research involving: integration with existing architecture; utilising only currently used (and food-safe) materials; zero impact or perceived impact on whisky production (exports to 175 countries and directly supporting 10,000 jobs); and the process must first and foremost be economically and environmentally sustainable [3.1, 3.2].

The key underpinning research was to overcome the challenge of accessing and recovering soluble protein from pot ale. As a protein resource, this was previously poorly utilised due to the inability to find a viable extraction process. From a small research project in early 2011, initial feasibility results showed promise in reversible adsorption of protein extraction using to low cost solid-phase adsorbents. This led to funding being secured from Scottish Funding Council in late 2011 [P1] for a postdoctoral researcher and the commencement of a PhD project.

The early research work built on both the initial findings and Willoughby's research background in developing therapeutic protein purification processes, while the postdoctoral side of the project focused on the commercial aspects, sustainability and life cycle analysis. The research findings resulted in a viable full process for recovery of protein components of value, with the critical finding [3.3] being the ability of the developed process to reversibly bind over 80% of the protein content of pot ale to a solid phase adsorbent, under normal pot ale discharge conditions. This protein can then be recovered as a pure solution, concentrated and dried [3.4]. Solid phase adsorption is a widely applied pharmaceutical and water treatment technology and is robust and easily scalable, but had never previously been used reversibly in-situ to recover usable protein.

The An alternative protein processing approach, involving reversible binding and often used for recovery of therapeutic and pharmaceutical-grade proteins, exploits reversible binding adsorbents in ion exchange chromatography. The adsorbents used in these processes, however, are far too expensive to be economically sustainable in the pot ale process, and their size and lack of rigidity would result in operationally challenging pressure drops in large scale columns.

Central to this technology was to identify a food-grade adsorbent that is widely available and economically viable. In addition, this adsorbent must have a high protein binding capacity, to ensure the process was viable at scale, and must have an open, microporous and rigid structure to ensure operational robustness and low-pressure drops at scale. After testing a number of solid phase candidates and identifying several promising possibilities, the research then moved into designing and validating a process with end-routes for all product and by-product streams [3.5, 3.6].

The success of the early project in developing a viable protocol allowed securing of further funds in 2014 from Scottish Enterprise for translational research [P2]. This allowed the research team to design, develop and manufacture a processing plant capable of treating pot ale on-site at distilleries. This plant was used for trials in 2015 and 2016 to improve understanding of processing conditions and to seamlessly integrate with current distillery architecture, as well as to produce enough protein to enable larger scale salmon feed trials in 2016/17. Further funding from the Industrial Biotechnology Innovation Centre (IBioIC) supported research exploring the broader potential of the technology within the grain whisky, grain spirit, US rye and bourbon processes [P3, P4]

The work was further supported via an RSE Enterprise Fellowship (2016) to better understand the commercial potential of the protein product in feed and food sectors.

The positive results in both the salmon trials and the demonstration of the process operating in distilleries allowed the commercialisation of the technology at this stage, with the IP being licenced to Horizon Proteins in 2016, and then fully assigned in 2020.

3. References to the research

[3.1] **Journal**. Whisky by-products: a valuable source of protein and potential applications in aquaculture (2014). White, J., Traub, J., Maskell, D.L., Hughes, P., Harper, A. Willoughby, N. New Biotechnology Vol. 31, S118, https://doi.org/10.1016/j.nbt.2014.05.1899

[3.2] **Conference**. Maskell, D.L., White, J., Traub-Modinger, J., Hughes, P., & Willoughby, N. (2016). Creating a new market opportunity for whisky by-products. In I. Goodall, R. Fotheringham, D. Murray, A. Speers, & G. Walker (Eds.), Worldwide Distilled Spirits Conference: Future Challenges, New Solutions (Vol. 5, pp367-370). Nottingham, United Kingdom https://researchportal.hw.ac.uk/en/publications/creating-an-new-market-opportunity-for-whisky-by-products-challen

[3.3] **Journal**. Characterisation of pot ale from a Scottish malt whisky distillery and potential applications (2020) White, J., Stewart, K., Maskell, D.L., Diallo, A., Traub-Modinger, J. and Willoughby, N. American Chemical Society, ACS Omega. Vol. 5, (Issue 12), pp6429-6440. https://doi.org/10.1021/acsomega.9b04023

[3.4] **Journal**. Batch anaerobic digestion of deproteinated malt whisky pot ale using different source inocula (2018) Barrena, R., Traub, J., Rodriguez Gil, C., Goodwin, J., Harper, A., Willoughby, N., Sánchez, A., and Aspray, T. Waste Management Vol. 71, pp675-682, https://doi.org/10.1016/j.wasman.2017.06.025

[3.5] **Patent** (granted 2019). #10,214,559 - 2019 (PCT/GB2015/051944 – 2015). Protein recovery. https://patents.justia.com/patent/10214559

[3.6] **Book**. Recovery and applications of proteins from distillery by-products. White, J., Traub, J., Maskell, D.L., Hughes, P., Harper, A. and Willoughby, N. (2016) In: Protein By-products. Transformation from environmental burden into value-added products. Chapter 13, pp235-253. Editor GS Dhillon. Elsevier.

https://doi.org/10.1016/B978-0-12-802391-4.00013-6

P1 - Willoughby (PI): Fermentation Process Co-Products: Integrated Protein, Energy and Feedstock Recovery, Scottish Funding Council Horizon Fund (GBP700,000) Sept 2011 – August 2014 (Includes industrial contribution)

P2 - Willoughby (PI): Horizon Proteins, Scottish Enterprise High Growth Spin Out Phase II/III (GBP665,000) involving (GBP527,000 academic research funding to ERPE, November 2014 – October 2016; GBP138,000 investment in the spin-out of Horizon Proteins from October 2016 onwards).

P3 - Maskell (PI): New world by-products, IBioIC Exemplar (GBP162,000), Jan, 2016 –Dec, 2016.

P4 – Maskell (PI): Sustainable Products: Innovation, Recovery and Integrated Technology, IBioIC Accelerator (GBP40,000), Feb, 2016 – Sept, 2016.

4. Details of the impact

The impacts arising from the underpinning research are parallel increases in economic and environmental sustainability in strategic key rural industry sectors, within both the whisky and aquaculture industries. A range of impacts have resulted involving local, national and international platforms supporting business development and key policies and strategies of the circular economy. The key impacts are as follows:

(A) New Spinout Company: Horizon Proteins Ltd (HP)

Researchers decided in 2014 to commercialise the emerging process and develop the research further via a spinout company. Funding was secured through Scottish Enterprise's elite High Growth Spinout Program (HGSP) to support the applied research transition. Horizon Protein Ltd (HP) was registered as a company in 2014 [5.1, 5.2] and full operations of the spin-out company commenced in 2016. HWU staff and HP subsequently identified a route to

economically separate the protein and Scottish Enterprise awarded GBP575,000 assistance [5.2], along with £138,000 industrial support, to refine the process in collaboration with distillers and aquafeed manufacturers [5.3]. At the announcement of the funding for HP, Eleanor Mitchell, Director of Commercialisation at Scottish Enterprise, said: "*We are very excited to be supporting a project with the potential to not only create high value jobs in Scotland, but to also provide such significant value-add to the iconic Scottish food and drink industries, salmon and whisky*".

By adapting techniques more commonly applied to high-value pharmaceutical products, HP developed the unique, cost-effective separation and extraction process [5.3]. Ultimately, it has managed to transform a historically underused by-product and increased the sustainability of various distillery processes [5.3].

In June 2015, a key circular economy report, commissioned by Zero Waste Scotland, Scottish Government, Scottish Environment Protection Agency and enterprise agencies, which included a 'Sector Study: Beer, Whisky and Fish', cited Horizon Proteins (HP) 24 times in the document. HP was described as a prime example of a company creating a circular economy that '*could offer a game-changing opportunity'* [5.4] coupling both whisky and salmon industries for the important '*meaningful contribution to rural economies'*, with the '*pot ale by-product sector valued at GBP80,000,000 being a realistic market sector value*' [5.4]. The report further stated that HP is a '*key development*' and '*a bonus as pot ale is in less competition with the cattle feed markets than draff. It may also offer a potential solution for smaller or isolated distilleries: Horizon Proteins is developing a form of their technology designed to operate at smaller scales'*.

In 2015 Horizon Proteins were invited by Scottish government to showcase their pioneering circular economy approach for the food and drink by-product sectors at the Milan Expo 2015 [5.5]. In 2016, HP was a case study cited by Arup Associates in a Mayor of London report 'Circular and Sharing Economy', as a specific example of an industry converting organic waste to proteins [5.6].

(B) Joint venture with Rothes CoRDe to build HPL Manufacturing Plant

Further key investment was raised in 2018, as a result of HP being engaged with the top two companies (Diageo and Pernod Ricard) producing more than 60% (by production volume) of Scottish whisky output. Funding of GBP4,000,000 was raised to support the construction of Horizon Proteins' first manufacturing plant, as a joint venture with Rothes CoRDe Ltd, on their site in Rothes, Scotland [5.7]. Funders included SiccaDania Venture [5.8], Danish high-net-worth individuals and the Scottish Investment Bank.

(C) New Production Plant - £4m investment supporting rural economy and jobs

The construction process for this plant is underway (delayed due to COVID-19) and will initially be able to treat 200,000 tonnes of pot ale per annum to produce around 2,500 tonnes per annum (tpa) of sustainable protein, expanding in 2023 to full capacity of 1 million tpa of pot ale and 12,000 tonnes tpa of sustainable protein. This plant has been designed to produce revenues of GBP2.25m initially, projected to rise to GBP11.25m at full capacity.

EWOS Cargill have agreed to purchase all of the initial protein, with a specific Scottish salmon farming customer as the first key client [5.9]. The construction of this plant will create around 10 skilled jobs in the Speyside rural area associated with the plant, as well as supporting in-direct supply chain roles (transport etc.).

(D) Economic Added Value

The Horizon Proteins research project was designed from inception to maximise economic impact for rural areas and researcher staff engaged key stakeholders from the whisky, aquaculture and feed industries as an advisory panel to guide direction. Researchers have engaged with the whisky industry through the Scotch Whisky Research Institute (SWRI) and the major trade body the Scotch Whisky Association (SWA), to ensure that all distillers had an input. The three major aquafeed manufacturers in Scotland, EWOS Cargill, BioMar and

Skretting, were all involved in the project during its development and all three offered to carry out commercial trials of the final product. This early engagement ensured that the commercial impact pathway of the developed process was maximised.

Extraction of this protein transforms the accessible value of these liquid waste by-products. They are worth around GBP3/tonne as pot ale sold as syrup, but this increases to GBP20/tonne, when reconstructed into the Horizon Proteins dried products, resulting in an over 600% increase [5.3].

(E) Environmental Benefits

The HP process enables a reduction in the chemical oxygen demand (COD) to treat the waste and reduces the needs for imported (non-UK sourced) aquafeed. The technology is now seen as a crucial element in the development of a circular bioeconomy and specifically 'upcycling' in Scotland [5.4]. The technology reduces environmental pollution, allows for re-use of water, lowers by-product processing costs and provides a sustainable source of protein for fish for a growing global population [5.1].

5. Sources to corroborate the impact

[5.1] News article (2016): 'Whisky chasers' - Information on spin-out company Horizon Proteins from Heriot-Watt University 2014.

https://www.hw.ac.uk/uk/research/impact/industry/whisky-chasers.htm

[5.2] 'Whisky' salmon feed firm Horizon Proteins wins funding', BBC News, Nov 2014 https://www.bbc.co.uk/news/uk-scotland-scotland-business-30145724

[5.3] Horizon Proteins, Chairman (named contact who will corroborate investment into Horizon Proteins)

[5.4] Circular Economy. 2015 Sector Study on Beer, Whisky and Fish Final Report, produced by Zero Waste Scotland, Horizon Proteins is cited 24 times in this 87 page document and specifically (p5, p16, p37, p53). https://consult.gov.scot/zero-waste-delivery/making-things-last/supporting_documents/ZWS645%20Beer%20Whisky%20Fish%20Report_0.pdf

[5.5] News of the exhibition Milan Expo 2015, Scottish government invited Horizon Proteins

https://www.heraldscotland.com/business_hq/13716822.scotlands-sustainable-food-and-drink-showcased-at-milan-expo/

[5.6] Circular and Sharing Economy Study. Mayor of London report, by Arup Associates, citing Horizon Proteins as an example case study of industry organic waste to proteins, p86 (2016)

https://www.london.gov.uk/sites/default/files/9._circular_and_sharing_economy_study_2018.pdf

[5.7] Rothes CoRDe Ltd, Managing Director (named contact who will confirm investment into construction of Horizon Proteins first manufacturing plant)

[5.8] SiccaDania Venture A/S, Managing Director (named contact who will confirm investment into construction of Horizon Proteins first manufacturing plant)

[5.9] EWOS Cargill Aquanutrition Commercial & Country Director CQN Scotland (named contact who will confirm agreement of purchase of all initial protein on production)