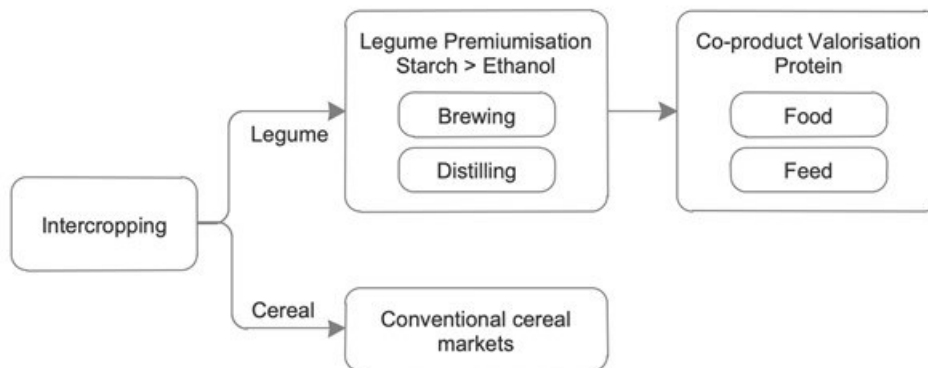


Impact case study (REF3)

Institution: Abertay University		
Unit of Assessment: 6 - Agriculture, Food and Veterinary Sciences		
Title of case study: Novel uses of legumes for sustainable agri-food industrial applications		
Period when the underpinning research was undertaken: 2015-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name: Graeme Walker	Role (e.g. job title): Professor	Period employed by submitting HEI: 1987-present
Period when the claimed impact occurred: 2015-2020		
Is this case study continued from a case study submitted in 2014? No		
<p>1. Summary of the impact</p> <p>Abertay-led research, in collaboration with colleagues from research institutes, universities and industrial companies, has provided tangible outcomes for legume-supported food and feed chains.</p> <p>Agri-food sectors benefitting from our research include:</p> <ol style="list-style-type: none"> growers (providing economic and environmental savings from cultivation of nitrogen-fixing legumes) brewers and distillers (producing novel legume fermented beverages) animal feed producers (using protein from brewing and distilling legume co-products) <p>Unique legume-based commercial products have emanated from our research, including an entirely new range of faba bean-based beers and the world's first <i>Climate Positive</i> distilled spirits (gin and vodka) that have met with international acclaim.</p>		
<p>2. Underpinning research</p> <p>Contextual information Industrialised agriculture relies heavily on the use of synthetic nitrogen fertilisers, but this has a deleterious influence on the environment through aquatic eutrophication, greenhouse gas emissions and subsequent climate change. Cultivation of legume crops (peas and beans) that biologically fix nitrogen from the atmosphere mitigates these impacts and, as outlined in this Case Study, offer sustainable alternatives to cereals for agri-food and beverage systems.</p> <p>Nature of the research Abertay University has led research, in collaboration with academic and industrial partners, that has revealed how legume starch and protein can be bioprocessed, respectively, into fermented beverages and high protein animal feeds. Our research, together with agronomic input on experimental field trials at the James Hutton Institute, has additionally shown significant environmental benefits when legumes are inter-cropped with cereals without fertilizer inputs. This research has also included Life Cycle Analyses of legume-based alcohol production revealing considerable global mitigation of greenhouse gas emissions and nutrient leakages to the environment.</p> <p>Underpinning research Fig. 1 outlines the main areas of the research focus at Abertay to exploit leguminous plants for sustainable agriculture and food production. These areas include:</p> <ul style="list-style-type: none"> - <i>Cereal-legume intercropping</i> - demonstrating reduced reliance on synthetic nitrogen (N) 		

- fertilisers for cereals
- *Legumes for brewing and distilling* - demonstrating bioconversions of legume starch to ethanol
- *Legume co-products for food and feed* – exploiting high-protein legume-based feeds

Fig 1. Abertay research into legumes for sustainable agri-food systems



Together with academic partners (Bangor University, National University of Ireland Galway, and Trinity College Dublin), we have demonstrated greenhouse gas (GHG) emission mitigation savings by employing legume starch for alcohol production. Using data generated by Abertay, a life cycle assessment (LCA) was undertaken to compare the environmental footprint of 1L of gin produced from either 1.43kg of wheat grain or 2.42kg of peas via fermentation and distillation. Allocated environmental footprints for pea-based gin were smaller than for wheat-based-gin across 12 of 14 environmental impact categories considered [3.1].

For the distilling [3.1, 3.2] and brewing [3.3, 3.4] sectors of industry, our research has shown that starch from faba beans (*Vicia faba* L) can be saccharified and further processed into spirits and beers [3.1, 3.5]. We have also been able to show, for the first time, the scaling-up of such technology (Section 4).

Agronomically, our experimental farm field trial research with the James Hutton Institute on legume-cereal intercropping has shown the feasibility of cultivating barley destined for brewing and distilling applications, without extraneous N-fertilisers, but with considerable environmental benefits [3.1, 3.6].

Overall, Abertay research and the novel bioprocess technologies developed at Abertay have successfully shown how to exploit legume starches for beverages and legume protein for feed production in a sustainable way.

3. References to the research

- 3.1 Leinhardt, T, Black K, Saget S, Porto Costa M, Chadwick D, Rees RM, Williams M, Spillane C, Iannetta PPM, Walker G, and Styles D (2019) Just the tonic! Legume biorefining for alcohol has the potential to reduce Europe's protein deficit and mitigate climate change. *Environment International*, 130, 104870 <https://doi.org/10.1016/j.envint.2019.05.064>
- 3.2 Walker, G, Ianieri, J, Moench, M, Palomba, G and Iannetta, P (2015) Potential of faba bean starch for distilled spirit production. In: *Distilled Spirits. Future Challenges & New Solutions*. Goodall, I, Fotheringham, R, Murray, D, Speers, A & Walker, GM (2015) Eds. Context Publishers, Nottingham, pp13-17 https://rke.abertay.ac.uk/ws/portalfiles/portal/31706694/Walker_PotentialOfFabaBeanStarch_Accepted_2015.pdf
- 3.3 Black, K., Barnett, A, Tziboula-Clarke, A, White, PJ, Iannetta, PPM and Walker, G (2019) Faba bean as a novel brewing adjunct: Consumer evaluation. *Journal of the Institute of Brewing*, 125(3): 310-314. <https://doi.org/10.1002/jib.568>

3.4 Iannetta, PM, James, EK, Hawes, C, Lopez Del Egido, L, Karley, A, Olukosi, O, Houdijk, J, Crampton, V, Moench, M, Palomba, G, Ianieri, J, Clark, F, Duncan, K, Squire, GR, Ramsay, G and Walker, G (2015) Enhancing the economic potential of beans using *Vicia faba* L.: Crop performance and the use of air-classified grain components in animal feeds and brewing. *Legume Perspectives* 8: 21-23 url: https://www.legumesociety.org/wp-content/uploads/2019/12/legum_perspect_8.pdf

3.5 Black, K, Tziboula-Clarke, A, White, PJ, Iannetta, PPM and Walker, G (2020). Optimised processing of faba bean (*Vicia faba* L.) kernels as a brewing adjunct. *Journal of the Institute of Brewing*, 127(1): 13-20. doi: <https://doi.org/10.1002/jib.632>.

3.6 Black, K., Walker, G., White, P., Squire, G and Iannetta, P (2018) Intercropped barley for brewing & distilling. In: *Distilled Spirits*. Ed. F Jack, D Dabrowska, S Davies, M Garden, D Maskell and D Murray Context Products Ltd, Packington, UK ISBN9781899043781. Chapter 9, pp45-48 url: https://rke.abertay.ac.uk/ws/portalfiles/portal/15161124/Walker_IntercroppedBarleyForBrewingAndDistilling_Author_2017.pdf

Funding: The Scottish Government's Strategic Research Programme is funding the collaborative legume research at Abertay University and the James Hutton Institute. This collaboration has additionally been supported by funding from the European Commission via the TRUE (Transition paths to sUustainable legume-based systems in Europe) project (www.true-project.eu).

4. Details of the impact

The nature and extent of the impact

Our research has benefitted growers who can exploit our novel legume-cereal intercropping regimes to lessen reliance on environmentally harmful fertiliser usage. It has also led to the introduction of several commercial legume-based products being marketed by breweries and distilleries. A new range of faba bean beers, and the world's first *Climate Positive* gin and vodka have been introduced to the marketplace following proof-of-concept research at Abertay. The latter products exploit an innovative use of an important leguminous crop, pea (*Pisum sativum* L.), as a source of starch for alcohol (gin and vodka) production. These processes additionally yield a protein-rich co-product that can be used as valuable animal feed.

Over the period 2015-2020, the following stakeholders in the agri-food sectors have benefitted from Abertay research into legumes as sustainable crops:

ABERTAY RESEARCH AREA	BENEFICIARIES	IMPACT	EVIDENCE
Legume-cereal inter-cropping	Agriculture sector: Cereal growers	Reduced N-input	Source 5.1
Brewing & distilling	Beverage alcohol sector: Brewers & Distillers	New beers & spirits	Sources 5.2, 5.3, 5.4
Legume co-products	Food & Feed sector: Livestock & Poultry farmers	High-protein feeds	Source 5.5

Legume-cereal inter-cropping

Abertay research in collaboration with the James Hutton Institute, and academic colleagues from Wales (Bangor) and Ireland (Galway and Dublin) has shown minimum GHG mitigation savings to be made using cereal-legume intercropping. This has been corroborated by the James Hutton Institute (JHI), whose Senior Scientist (Dr Pietro Iannetta) has stated:

"The JHI-Abertay collaboration on legume-cereal intercropping field trials has shown that greater nutrient use efficiency (and commodity protein contents) can be achieved in addition to

significant greenhouse gas emissions mitigation when cultivating pulses alone or in combination (intercropping) with cereals. Farmers throughout the UK have sought agronomic advice from the research team to increase the acreage of pulse cropping” [5.1].

The consequential annual economic savings of our legume research to commercial Scottish growers, in terms of greatly (>80%) reduced fertilizer applications, has been calculated at £13.3m, together with CO₂e savings of 420 kt.

In Scotland, growers have specifically benefitted from our field trial data with advice and guidance on barley-pea intercropping densities. This is especially important for Scottish barley production where our research has shown that two-thirds of the cropped area devoted to these cereal and commercial intercrops can now be grown with confidence. This adds benefits beyond 80% reduction in N fertilisers, including higher yields of 10-20% per hectare and greater yield stability (reduced year on year variability).

Brewing and distilling

Novel beverage products made using faba beans have emerged from work conducted at Abertay. These include a completely new range of beers that have been produced following our work. For example, the owner and founder of Barney’s Brewing Co. has stated:

“For the past 6 years, we have been working closely with Abertay University to develop new environmentally-friendly beers made from beans. Although there are some technical difficulties with using beans compared with cereals in brewing, Abertay researchers have helped us develop a range of commercial products, including: Fe Fi Fo, official beer of Edinburgh Science Festival 2015; Tundra IPA, launched in 2017, containing 40 % faba bean; Jack IPA, launched in 2017, containing 50 % faba bean and Cool Beans (Fig. 2), launched in 2018, containing 40 % faba bean” [5.2].

Cool Beans represents the company’s first gluten-free vegan product and was shortlisted for Speciality Beer of the Year at the 2019 Scottish Beer Awards. The product is highly competitive, catering for mainstream as well as gluten free and vegan friendly markets. It has been very beneficial for the company from both a reputational and economic standpoint. The brewery owner has stated:

“The development and production of these beers would not have been possible without the proof-of-concept research conducted at Abertay University” [5.2].

As a result of our faba beans research, brewing companies from across the UK, Europe and internationally (including USA and Canada), are now looking to exploit more sustainable raw materials such as legumes in their production processes.



Fig 2. Faba-based beer (*Cool Beans*) (© Barney’s Brewing Co.) and pea-based *Nadar* gin and vodka (© Arbikie Distilling Ltd.) produced following Abertay research.

Novel distilled spirit beverages have also been produced in collaboration with Arbikie Highland Estate Distillery (Angus, Scotland). With over 60 gin distilleries, Scotland is the UK’s largest producer of gin and Arbikie is one of the few Scottish distillers where all ingredients are grown

on their single estate farm. The world's first *Climate Positive* gin (called Nàdar, Gaelic for Nature, Fig. 2) was developed by Abertay research and launched to the marketplace on February 19, 2020 receiving extensive global media and press coverage from the BBC, ITV, Sky News, and national and international worldwide newspapers [5.3]. This product, together with Nàdar vodka which launched in September 2020, was created in collaboration with Arbikie Master Distiller, Kirsty Black, following research at Abertay [3.1]. Each 700ml bottle of Nàdar gin has a carbon footprint of -1.54 kg CO₂e (carbon dioxide equivalent), meaning it avoids more carbon dioxide emissions than it creates. This environmental performance – much better in comparison to traditional wheat-based gins – was achieved by utilising waste from the distilling process and taking advantage of the natural properties of peas as a sustainable green- fertiliser. John Stirling, Director of Arbikie Distillery stated:

“Nàdar Gin has been researched and developed at Abertay University. The launch of this novel product has proved very beneficial to our company in terms of a marketing/PR and financial viewpoint and would not have been possible without the fruitful research collaboration between ourselves and Abertay University” [5.4].

Legume co-products

The residues from legume-based brewing and distilling processes, known in the industry as co-products, have been analysed at Abertay and subsequently trialled as high-protein animal feeds. Arbikie distillery's *Nàdar* pea gin pot-ale (distillate residue) is now being used as a cattle feed. In addition, poultry feeding trials in collaboration with the Monogastric Science Research Centre in Edinburgh of faba bean co-products from Barney's Brewing Company have also proved successful [5.5]. Overall, the high environmental costs of imported animal feeds are offset, since most of the latter are often derived from soybean commonly sourced from cleared rainforest and cerrado regions.

Wider reach of our research into legume-supported food and feed chains has also occurred. For example, Dr Pietro Iannetta, an agroecologist at the James Hutton Institute, has stated:

“The research collaboration with Prof. Walker and his colleagues at Abertay University and James Hutton Institute into exploitation of legumes for food and drink applications has been exceptional, resulting in several tangible benefits from a societal, environmental and industrial standpoint. This has extended to the influencing provision of policy advice regarding the potential of legumes to the Scottish Government” [5.1].

Furthermore, our research into novel uses of legumes was presented to The Scottish Parliament in 2018 and formed a Scottish Government case study (Sustainable Alcohol Production for Scotland) in 2020 evidencing the impact of investments in academic research & knowledge exchange [5.6].

5. Sources to corroborate the impact

- 5.1** Testimonial from Dr Pietro Iannetta, Senior Scientist, James Hutton Institute. *Provides corroboration of Abertay research demonstrating environmental benefits of cultivating legumes for growers and the beverage alcohol industry*
- 5.2** Testimonial from Andrew Barnett, owner of Barney's Brewing Co. *Provides corroboration for commercial production of novel faba bean beers based on Abertay research*
- 5.3** Summary of press and media coverage of Nàdar Climate Positive distilled spirits
- 5.4** Testimonial from John Stirling, Director and owner of Arbikie Highland Estate. *Provides corroboration of the commercial impact of Nàdar gin, developed by Abertay*
- 5.5** Testimonial from Prof Jos Houdijk, Head of the Monogastric Science Research Centre, Scotland Rural College. *Provides corroboration of poultry nutritional benefits of faba coproducts from brewing*
- 5.6** Sustainable Alcohol Production for Scotland. *Scottish Government Case Study presented as evidence of impact from the investments in academic research and knowledge exchange*