TResearch

Volume 17: Number 3: Autumn 2022
ISSN 1649-8917

PIG DEVELOPMENT
A hands-free approach to pig research

FOOD SAFETY
Identifying bacteria in food production

BENEFITS OF KELP
Exploring kelp's ability to treat health conditions

INTERVIEW
John Tobin offers an insight into industry collaboration
pp.28-29

Clearing the air

Reducing greenhouse gas emissions within the agriculture sector is a priority for our researchers

Teagasc
Agriculture and Food Development Authority

Welcome

Reducing greenhouse gas (GHG) emissions within the agriculture sector is a priority for our scientists. This pressing need was recently highlighted once again with the government's announcement that a 25% reduction in GHG emissions is required within the agriculture sector by 2030.

In this issue, we spoke to a team of sheep researchers from Athenry who are establishing a technique that allows them to rank sheep based on methane output, in order to generate breeding values for methane production (p18). The Teagasc team (Fiona McGovern, Noirin McHugh, Eoin Dunne and Edel O'Connor) is currently the only group in Ireland looking directly at methane emissions from sheep systems.

Promisingly, the next generation of scientists are gearing up to understand climate change and possible mitigation strategies better. We interviewed a number of current Teagasc Walsh Scholars to find out more about the focus of their PhD research (p13). One of our scholars, Kieran Harrahill, is looking at the bioeconomy; his work aims to replace products that come from fossil fuels with more sustainable products, for example plant and animal waste. Another scholar, Ali Sultan Khan, is looking at the sustainability of biogas and biomethane production in Ireland.

We also have insights from Teagasc experts who have been exploring ways to help beef farms meet both economic and environmental targets (p34). Having shared their findings at BEEF2022 – Teagasc's Beef Open Day – Paul Crosson and colleagues recap the key technical messages beef farmers need to know.

Catriona Boyle
Editor, *TResearch* magazine, Teagasc

Tá laghdú astaíochtaí gás ceaptha teasa (GHG) laistigh den earnáil talmhaíochta ina thosaíocht dár n-eolaithe. Tarraingíodh aird an athuair ar an ngéarghá seo nuair a d'fhógair an rialtas go dteastaíonn laghdú 25% in astaíochtaí GHG ón earnáil talmhaíochta faoin mbliain 2030.

San eagrán seo, labhraíomar le foireann taighdeoirí caorach i mBaile Átha an Rí a bhfuil teicníc á forbairt acu a ligfear do chaoirigh a bheith rangaithe bunaithe ar aschur meatáin. Fágfaidh sé sin go mbeifí in ann luachanna pórúcháin a ghiniúint maidir le táirgeadh meatáin (lch 18). Is é foireann Teagasc (Fiona McGovern, Nóirín McHugh, Eoin Dunne agus Edel O'Connor) an t-aon grúpa in Éirinn faoi láthair a bhfuil staidéar díreach á dhéanamh acu ar astaíochtaí meatáin ó chórais caorach.

Údar dóchais é go bhfuil an chéad ghlúin eile eolaithe ag fáil faoi réir tuiscint níos fearr a fháil ar athrú aeráide, agus ar straitéisí maolaithe féideartha. Chuireamar agallamh ar roinnt de Scoláirí Walsh Teagasc reatha chun tuilleadh eolais a fháil faoin taighde PhD atá ar siúl acu (lch 13). Tá staidéar á dhéanamh ag duine dár scoláirí, Kieran Harrahill, ar an mbithgheilleagar; tá sé ag obair ar bhealaí chun dramhaíl plandaí agus ainmhithe a úsáid chun táirgí a thagann ó bhreoslaí iontaise a athsholáthar le táirgí níos inbhuanaithe. Tá scoláire eile, Ali Sultan Khan, ag déanamh iniúchadh ar inbhuanaitheacht táirgeadh bithgháis agus bithmeatáin in Éirinn.

Tá léargais againn freisin ó shaineolaithe Teagasc a bhfuil bealaí á bhfiosrú acu chun cabhrú le feirmeacha eallach mairteola a spriocanna eacnamaíocha agus comhshaoil araon a chomhlíonadh (lch 34). I ndiaidh dóibh a bhfuil faighte amach acu a roinnt ag BEEF2022 – Lá Oscailte Mairteola Teagasc – tugann Paul Crosson agus a chomhghleacaithe achoimre ar na príomhtheachtairechtaí teicniúla ar cheart d'fheirmeoirí mairteola a bheith ar an eolas fúthu.

Catriona Boyle
Eagarthóir, iris *TResearch*, Teagasc

TResearch is an official science publication of Teagasc. It aims to disseminate the results of the organisation's research to a broad audience. The opinions expressed in the magazine are, however, those of the authors and cannot be construed as reflecting Teagasc's views. The Editor reserves the right to edit all copy submitted to the publication.

www.teagasc.ie

EDITOR
Catriona Boyle
catriona.boyle@teagasc.ie

ADMINISTRATOR
Gayle Tara-Moore
gayle.taramoore@teagasc.ie

Published on behalf of Teagasc
Artful Dog Publishing
artfuldogpublishing.com

Design: *Ross Behenna; Asami Matsufuji*
Editorial: *Isabel Overton*

Cover image: Andrew Downes

Contents

The future is (Ful)bright

Teagasc Walsh Scholar Conor Hammersley has been named a 2022 Fulbright-Teagasc Awardee. Sponsored by the Fulbright Irish Scholar Awards, which provides grants for Irish citizens to conduct research in the USA, Conor will spend 10 months at the prestigious Columbia-Bassett Medical School in New York. There, he will research the evolving socio-cultural and economic challenges that farmers in the USA face in relation to their health, compared to those encountered by farmers in Ireland. His research will support the development of strategic health interventions developed in the USA, to aid in the development of support in Ireland.

Conor has been researching farmer health at Teagasc through his project On Feirm Ground, which explores modern-day barriers encountered by farmers in relation to their health. It also seeks to support the development of a national farmers health training programme targeted at agricultural advisors, to engage farmers on health issues. Furthermore, his research looks to inform intervention strategies to support farmer wellbeing.

Conor Hammersley (fifth from right) with his parents, representatives from Teagasc and representatives from the South East Technological University

Apply now: 2023-2024 Fulbright Irish Scholar Awards applications are now open. Candidates interested in a scholarship in the USA can find more information on www.fulbright.ie

Succession Farm Partnerships

Teagasc has been instrumental in establishing farm partnerships as a widely used trading structure for farms, developing legally binding partnership templates to govern their operation.

As well as helping to establish Registered Farm Partnerships – where two or more farmers join resources and efforts in order to acquire various benefits – Teagasc has been instrumental in the development of Succession Farm Partnerships (SFPs).

SFPs are a specific purpose partnership arrangement that facilitate an organised transfer of farm business assets, as part of a formalised farm transfer. There are currently over 130 SFPs on the Department of Agriculture, Food and the Marine register.

Benefits of SFPs:

€5,000 tax credit
SFP arrangements are supported by enhanced tax relief.

Defined succession plan
Farms are automatically transferred to successors at the end of a specified period.

Financial, social and CAP scheme benefits
Benefits include a better work-life balance, improved age structure and stock relief.

SFP regulations:

40 Successors must be under 40 years of age.

80% A minimum of 80% of farm assets must be transferred. Up to 20% can remain with the transferor.

10 Farm assets must be transferred after year three and before the end of year 10 of the agreement.

Off to a great START

The 2022 recipients of the START fund – a new initiative where Teagasc researchers can get up to €15,000 of funding to research concepts that have the potential to become spinout opportunities – have been announced. The selected researchers were chosen by a panel of external judges. The research areas being funded include:

- Pet ageing and wellness (**Maria Hayes**, Senior Research Officer)
- Probiotics for sows (**Peadar Lawlor**, Principal Research Officer)
- Food packaging (**Shivani Pathania**, Research Officer)
- BioHealth novel functional food ingredients (**Emer Shannon**, Research Leaders 2025 Fellow, and **Maria Hayes**).

The START fund has been launched by Teagasc's Technology Transfer Office. Recipients of the fund have a wide scope of options for how to use the funding, including developing a prototype, carrying out additional research or engaging a commercial consultant for customer discovery, business planning or intellectual property due diligence.

Teagasc researcher attends 71st Lindau Nobel Laureate Meeting

Kamaljit Moirangthem, a Teagasc Research Leaders 2025 and Marie Skłodowska-Curie Fellow, was one of 611 young scientists from 91 countries invited to the 71st Lindau Nobel Laureate Meeting this summer. This year, the annual scientific conference ran from 26 June to 1 July.

Since their foundation in 1951, the Lindau Nobel Laureate Meetings have developed into a unique international scientific forum, providing an opportunity for exchange between different generations, cultures and disciplines.

Kamaljit Moirangthem poses for a selfie with Countess Bettina Bernadotte of Wisborg, President of the Council for the Lindau Nobel Laureate Meetings.

Kamaljit qualified under a global multi-step selection process to participate in the meeting.

His research is focused on ways to turn spent grain waste from beer production into functional food ingredients.

"The 'Lindau Experience' was a pleasant highlight of my young scientific career," says Kamaljit. "I am honoured, inspired and motivated to have exchanged thoughts with Nobel Laureates and excellent open-minded young scientists from across the globe."

Want easy access to the latest Teagasc updates?
Subscribe to our e-newsletter by emailing gayle.taramoore@teagasc.ie or search Teagasc on LinkedIn and subscribe to our newsletter there.

News in brief

30 researchers took part in the Catalysing Connections pilot programme

30 Teagasc's Technology Transfer Office recently piloted **Catalysing Connections** – a five-month-long programme designed to inspire the **next generation of agricultural technology** entrepreneurs through working on innovative solutions to key research challenges. Thirty post-graduate and post-doctorate researchers from across the VistaMilk SFI Research Centre took part in the pilot.

Teagasc researchers are contributing to the **EU-funded IDEA+ capitalisation project**, which looks at applications of microalgae in fertilisers, foods, feeds and cosmetics. As part of the project, researchers extracted **algal oil** for use in cosmetics, and proteins from **microalgae** have been added to foods and animal feeds for their health benefits.

7 A paper co-authored by Teagasc researcher Mohammed Gagaoua has been published in scientific journal *PNAS Nexus*. The paper, titled ***Seven steps to enhance open science practices in animal science***, lists a number of recommendations for researchers, including how to share and code data, preprint findings, publish articles under open access and participate in open peer review.

Johannah Piggot, who won the **Teagasc Special Prize at BTYSTE 2022** at the beginning of this year, visited Teagasc Ashtown for a tour of the facilities recently. Johannah toured the Mushroom Tunnels and glasshouse and inspected the hedgerows for insect species. The project that won Johannah the award looked at the use of entomopathogenic nematodes (EPN) as an alternative to the use of pesticides for the control of plant insect pests.

Caption: (L-R) Jane Kavanagh (Teagasc), Johannah Pigott, Joanne Corkery (Colaiste Treasa), John Spink and Michael Gaffney (Teagasc)

Close(r) to the mark

Information derived from analyses of livestock DNA has proven to be more accurate than traditional pedigree information, providing benefits to breeding.

Over the past couple of decades, livestock breeding programmes have improved the performance of various production systems. The basis of such breeding programmes is the estimation of individual animals' genetic merit (more commonly referred to as estimated breeding values) via genetic evaluations.

Such estimates enable the ranking and subsequent selection of sires and potential replacements based on their estimated breeding values for various traits of importance.

David Kenny, Post-doctoral Researcher at Teagasc, says: "A critical consideration associated with breeding decisions based on estimated breeding values is the accuracy or reliability associated with those same values."

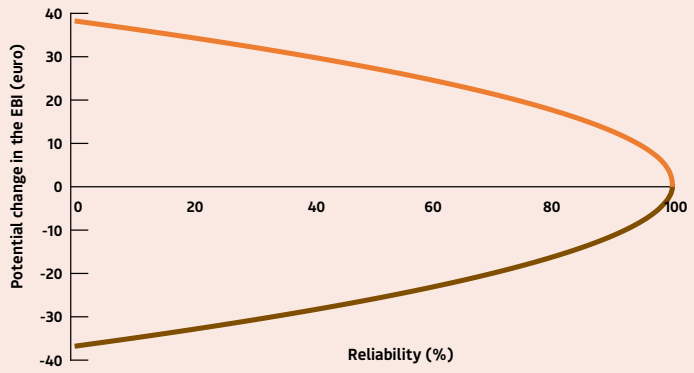
Such a measure reflects the extent to which breeding values in the Economic Breeding Index (a profit index aimed at helping farmers identify the most profitable bulls and cows) could potentially change, relative to their current prediction (Figure 1).

Estimating genetic merit

The reliability associated with an estimated breeding value is a function of the heritability of the trait (i.e. the proportion of the performance differences between animals that can be attributed to genetic differences), as well as of the type and quantity of available information for the estimation of the breeding value.

"The information traditionally used in genetic evaluations comprises performance information from the animal in question or from the animal's relatives or both," says David. "This features alongside information describing the relationship between animals within the national herd, such as pedigree information."

Figure 1. Potential change in the Economic Breeding Index (EBI) at different reliabilities.



DNA information represents a source of information to determine the relationship between individual animals within the national herd

Pedigree information, plus the fact that parents are expected, on average, to share half their DNA with their progeny, enables the estimation of an animal's genetic merit based on performance information from that animal's relatives.

The framework of genetic evaluations ensures that a higher emphasis is placed on performance information from animals that are more closely related (i.e. animals that are more genetically similar) to an animal of interest in the estimation of breeding values for that animal, than information from that animal's more distant relatives.

Measuring relationships using DNA data

Apart from pedigree information, DNA also represents a source of information to determine the relationship between individual animals within the national herd and, in turn, to estimate breeding values for related animals with no performance information. The use of DNA for such purposes is referred to as genomic selection.

Over and above that of pedigree-based methods, genomic selection has been

reported to increase the reliability associated with estimated breeding values by up to 35%. This increase in accuracy can primarily be attributed to the fact that DNA can more accurately measure the actual relationship between animals.

Donagh Berry, Principal Research Officer at Teagasc, explains: "The *actual* relationship between animals tends to not align exactly with the *assumed* relationship between animals that is derived from pedigree information.

"This is due to the biological reality that, while cattle pass half their DNA onto their progeny, different combinations of the parents' DNA is condensed and passed onto its eventual progeny."

In other words, while progeny do inherit approximately 50% of the parents' DNA, full-siblings do not inherit the exact same 50% of their parents' DNA.

Generating accurate breeding values

Based on pedigree information, full siblings are assumed to share 50% of their DNA. Investigation of DNA from Irish sheep and cattle populations recently determined that full siblings do, in fact, share 50% of DNA on average, but genetic relationships between them deviate from this average.

Excluding extreme values, it was determined that the genetic relationship between siblings could be as low as 38.9% and 38% in sheep and cattle, respectively, and as high as 61.1% and 62%.

Discussing the working example provided herein, Pierce Rafter, Post-doctoral Researcher at Teagasc, says: "The genetic relationship between full siblings, based on DNA, differ by up to 22.2% and 24% in sheep and cattle respectively. This is important with regard to generating more accurate breeding values, as performance-recorded animals that are genetically more similar to an animal of interest receive a greater emphasis in the calculation of that animal's breeding value.

"On the other hand, the opposite is true for animals less genetically similar to the animal of interest. Using pedigree data, such animals are assumed to have the same genetic relationship (i.e. 50%) and, thus, receive equal emphasis in the calculation of breeding values for an animal of interest."

Similarly, DNA can detect genetic relationships between animals for which no genetic relationship would be detected based on their pedigree information.

The ability to precisely infer the genetic relationship between two animals using genotype information has, therefore, not only enabled an increase in the performance data available, but also the ability to place greater emphasis on such data from animals that are more genetically similar to animals of interest, in the calculation of breeding values. T

FUNDING

This work is funded by VistaMilk SFI Research Centre.

CONTRIBUTORS

David Kenny
Post-doctoral Researcher
Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Co. Cork.

Pierce Rafter
Post-doctoral Researcher
Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Co. Cork.

Donagh Berry
Principal Research Officer
Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Co. Cork.
donagh.berry@teagasc.ie

Look but don't touch

By studying milk, faeces and saliva, researchers at Teagasc, the University of Leon and the University of Murcia are gaining a better understanding of piglets – without even touching them.

Piglets are born completely dependent on the sow, but they develop very fast into independent and resilient animals. This transition is accelerated in commercial farms – it happens in just four weeks!

Accelerating a process like this involves specialised management, supplementary food that is often the same quality as baby formula and, sometimes, veterinary support through the use of antibiotics.

Having a good understanding of what takes place during these four weeks is key to improving the health and welfare of piglets, and to maximising their growth without the need for veterinary support.

Milk plays a main role in this context because it is the only food that the piglet will have during this time. It is not only a source of nutrients for the piglet, but a way the sow passes all the relevant information that the piglet needs to face the challenges that are coming, e.g. pathogen exposure and organ development.

Edgar García Manzanilla, Head of Pig Development Department at Teagasc, says: "Understanding the information contained in the milk of the sow would allow us to understand the development of the piglet. This could then be optimised in commercial conditions."

Studying this development is challenging, however, because piglets suffer stress with any manipulation. Stress changes the physiology of the animal very quickly, and many of the parameters change in seconds.

Piglets suffer stress with any manipulation, so studying their development requires non-invasive methods

"A piglet that is handled for one minute for blood sampling may be so stressed that the CO_2 in its blood reaches levels that would kill a person," explains Edgar. "That is why using samples that are not invasive – like milk, faeces or saliva – is a more desirable alternative."

The use of non-invasive samples needs further research and development, which is what Edgar and other researchers from Teagasc, the University of Leon and the University of Murcia are delivering through their Milkobiome project.

The magic of colostrum

Colostrum is the first milk that piglets, like most mammals, receive when they are born. Mammals produce colostrum immediately following the delivery of a newborn, and it lasts between 24 and 48 hours after birth.

The Milkobiome researchers have carried out a first analysis of sow colostrum composition in detail, and found a more radical and controlled change from colostrum to milk than expected.

"We already knew that colostrum is much richer than milk in antibodies," says Edgar, "as the piglet needs it for immune protection. However, what we also found was a surprisingly higher content of the protein lactoferrin, long chain omega-3 fatty acids and rare oligosaccharides (a special type of carbohydrate). All of these have profound modulatory effects on the immune system and functions that are still to be discovered."

> **Incredibly valuable information about pig development can be obtained from studying saliva.**

Going with the gut

The researchers have also conducted a first analysis of bacterial populations in piglets, which revealed interesting new information on the composition of the gut microbiome of the animal.

Until now, most of the research on pig microbiome has used a technique called 16S analysis. The Milkobiome project is using a more effective approach – next-generation sequencing. This technology identifies the bacterial species in more detail and allows the researchers to understand the metabolic functions of bacterial populations.

Initial results have shown that the big homogeneous population of lactobacilli previously described with 16S is in fact a group of very diverse species of bacteria with a wide range of metabolic functions. This finding opens new opportunities to optimise piglet health.

The story saliva tells us about pig health

The use of saliva to understand the physiology of animals is not new. However, the extent to which it has been used in this project is unprecedented.

"Saliva was underestimated in the past as a fluid for veterinary use, but now researchers know how much valuable information can be obtained from this fluid," says Edgar. "All it takes to collect saliva is a piece of sponge or a rope that the piglets chew for a few minutes."

The project team has collected saliva from piglets and sows at different stages before and after birth, and analysed 25 biomarkers for inflammation, specific immunity and oxidative status, among others.

The group will also analyse the microbiome of saliva. Saliva is the best type of sample to understand the effect of the environment on the microbiome of pigs. This is because they root all day, and sample literally every single stone in the environment.

The findings found from these non-invasive studies are promising, and help our researchers to build a clearer picture of how milk and microbiota affect future intestinal health in pigs. T

FUNDING

The Milkobiome project has received funding from the Research Leaders 2025 programme, (co-funded by Teagasc and the European Union's Horizon 2020 Research and Innovation Programme) under the Marie Skłodowska-Curie grant agreement number 754380.

The work on saliva and microbiome is funded by the BM-Farm project (International Co-ordination of Research on Infectious Animal Diseases).

CONTRIBUTORS

Apeh Akwu Omede
Research Leaders and Marie Skłodowska-Curie 2025 Fellow
Pig Development Department
Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Co. Cork.

Edgar García Manzanilla
Head of Pig Development Department
Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Co. Cork.
edgar.garciamanzanilla@teagasc.ie

Lorena Franco Martinez
Post-Doctoral Researcher
Pig Development Department
Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Co. Cork.

Hector Rodriguez Argüello
Researcher
Department of Animal Health
University of Leon, Spain

Going organic in Ireland

The EU's Farm to Fork strategy aims to increase organic food production; knowing why consumers purchase organic foods will be essential if it is to be successful.

Producing food, regardless of type, comes at a cost to the environment, with estimations suggesting it accounts for approximately 30% of total greenhouse gas emissions.

To address this, farmers and food producers may need to reconsider conventional methods of agricultural production in favour of more benign and environmentally friendly methods, without necessarily sacrificing their profits or cutting production volumes. But do methods exist that are both safe for the environment and good for the farmer's bottom line? Moreover, are consumers in Ireland ready to buy and consume such food?

The rise of organic farming

Organic farming has long been touted as an alternative to conventional agricultural production. While it certainly does not address all the impending challenges of modern agriculture, organic farming offers an alternative system by prohibiting the use of chemical fertilisers. It also markedly restricts the application of other chemicals, such as plant protection in plants and antibiotics in animals. The environmental benefits this brings comes at a cost, however, as productivity may decrease.

Recently, organic farming has received renewed public attention across the EU as a new plan promoting the proliferation and uptake of organically produced food was announced as part of the Green Deal and

RossHelen /iStockphoto.com

2%

At present, less than 2% of agricultural land is being organically cultivated in Ireland.

Farm-to-Fork strategy. This plan envisages a considerable increase for land under organic cultivation (which should rise to 25% of the total agricultural area in just 10 years from today's average of 8.5%) as well as measures stimulating consumer demand for such food.

For Ireland, this plan represents an even bigger challenge as currently less than 2% of agricultural land is being organically cultivated. Furthermore, little is known about the preferences of Irish consumers for organic food to determine the market for these foods.

A consumer view of organic food purchasing

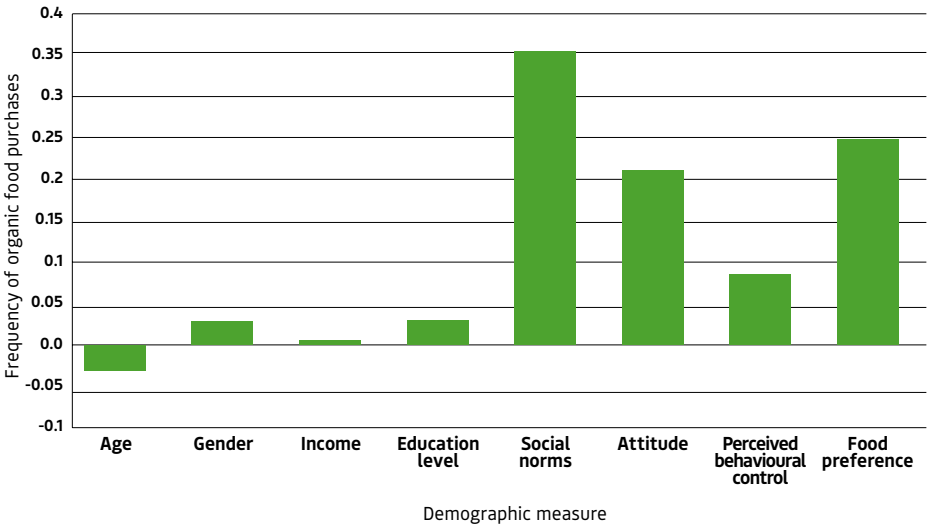
As part of the Circular Agronomics project, researchers at Teagasc, National University of Ireland, Galway (NUI Galway) and the Centre for Agro-food Economics and Development (CREDA) conducted an exploratory survey on 400 Irish adults in spring 2021, to examine factors relating to sustainable food behaviours, including organic food purchasing.

Analysis of the data (Figure 1) shows that the traditional demographic measures that are usually associated with organic purchasing, such as age, gender, education and income, had little or no impact in this survey. What was found to be most impactful in determining organic food purchasing was positive attitudes to organic food. Consumers who considered organic food to be more tasty, who supported animal welfare and who wanted food grown without chemicals were more likely to purchase organic foods.

Social norms, which describes the impact of friends and significant others on respondents' consumption decisions, positively influenced the decision to purchase organic foods. The impact of behavioural control, which is consumers' perceived ability to recognise, find and buy organic foods, was important for purchasing organic foods.

In addition, those who also tended to purchase fair trade foods and foods with sustainable attributes were more likely to purchase organic foods.

Figure 1. Influences on organic food purchasing behaviour in Ireland



Marketing campaigns to increase consumer demand and uptake of organic food purchasing should consider attitudes, social norms and behavioural control rather than focus on the traditional demographic segmentation categories, in order to be effective. Focusing on the impact of social norms on organic food purchasing will serve to increase the uptake of organic food purchasing in others. This in turn will help to form positive attitudes to organic foods that will also increase purchases.

For these measures to work, consumers need to have a sense of control over their purchasing behaviour. Hence, the availability of organic products in-store or at food markets should be highlighted and promoted so that the products are readily available and recognisable to consumers.

These findings can be used to inform policies regarding organic food purchasing, which in turn may encourage the transition to organic farming to meet targets set out in the EU Green Deal. T

FUNDING

The Circular Agronomics project is funded from the European Union's Horizon 2020 research and innovation programme, under grant agreement number 773649.

CONTRIBUTORS

Dmytro Serebrennikov
Teagasc Food Research Centre, Ashtown, Co. Dublin.

Sinéad McCarthy
Teagasc Food Research Centre, Ashtown, Co. Dublin.
sinead.mccarthy@teagasc.ie

Fiona Thorne
Teagasc Food Research Centre, Ashtown, Co. Dublin.

Zein Kallas
Centre for Agro-food Economics and Development (CREDA), Spain.

xiljan/iStockphoto.com

Significant investment has been made in the precision fermentation space in recent years

The future of protein production

The use of precision fermentation to produce proteins is on the rise in the food industry, so what does this mean for the livestock industry?

Words by: Paul Wood, Adjunct Professor at Monash University, Australia

Precision fermentation is the engineering of a protein's gene sequence into a bacterium or yeast strain, before growing that strain in large-scale fermenters to produce the protein that you require. This technology has been around for years in the biotechnology sector, and is used for many vaccines and drugs.

In the food sector, precision fermentation has been used for decades to produce enzymes for cheese production or conventional fermentation. In fact, cheese manufacturers now use precision fermentation to produce chymosin – one of the main enzymes responsible for milk coagulation – having previously extracted the enzyme from the stomachs of calves.

Engineering proteins for dairy and meat

A significant investment in the precision fermentation space has led many to predict that this technology is going to disrupt the traditional dairy industry.

Food technology company Perfect Day was the first to release a commercial dairy product containing beta lactoglobulin – a major whey protein of cow's and sheep's milk – derived using precision fermentation. Others are following this approach – several companies have goals to recreate a liquid milk containing both the whey and casein proteins, to give the product the full functionality of cow's milk. It's worth nothing, though, that these products will still need fats, sugars, minerals and vitamins added to replicate the nutritional content of cow's milk.

It is not just dairy being impacted either. Recently, companies have been looking to use this process to produce key proteins for the meat industry. Plant-based food manufacturer Impossible Foods uses a precision fermentation form of haemoglobin to give its burgers the look and smell of red meat when they are cooked. And biotechnology company The EVERY Company is producing chicken-free egg products with precision fermentation technology.

Roadblocks to implementing precision fermentation

While technological advancements are being made, there are many technical, regulatory and consumer challenges that will need to be overcome before it can be considered for mainstream use.

The major technical challenge will be the cost of goods, as precision fermentation is significantly more expensive. For milk proteins, a range of yeast strains can produce recombinant proteins (genetic material from two different sources) at a rate of 10–30 grams per litre. These proteins need to be separated from the yeast cells and cell debris using a variety of downstream processing that can account for up to 60% of the cost of manufacturing. Precision fermentation companies are looking at using fermenters at greater than 100,000L capacity, which will require complex engineering and energy intensive processes.

~60%

Around 60% of the companies in the precision fermentation space are focusing on the production of one or more of the six key dairy proteins.

Those in Europe also face a regulatory challenge, as it is currently difficult to register precision fermentation products because they use genetically modified organisms (GMO) in the manufacturing process.

Finally, the labelling of precision fermentation products will vary considerably in different regions, and this has the potential to confuse consumers who are cautious of GMO products.

Based on these issues, I feel precision fermentation will be unlikely to disrupt the livestock industry just yet. It will, however, provide high-value products for niche markets. T

Meet the Scholars

The Teagasc Walsh Scholarships Programme offers fantastic opportunities for postgraduate students wishing to pursue a PhD. For a better insight into what it is like to do a PhD, we spoke to several Walsh Scholars to hear their experiences and what they have learned.

Ali Sultan Khan

Ali is from Islamabad, Pakistan, where he completed a Bachelor of Science with agronomy majors at Pir Mehr Ali Shah Arid Agriculture University. He then moved to South Korea to complete his master's degree in Agricultural Science at Kyungpook National University. During the Covid-19 pandemic, Ali started a PhD at Teagasc Johnstown Castle Environment Research Centre.

What made you decide to undertake a PhD?

Having seen the devastating impact of climate change on my home country, I became very interested in communicating about the subject with a wider audience. I was attracted to Teagasc's tremendous previous and current research initiatives regarding strategies for climate change mitigation, which is why I chose to pursue my PhD here.

What does your research focus on?

The sustainability of biogas and biomethane production in Ireland through anaerobic digestion of slurry and various grass feed stocks.

What do you enjoy most about doing a PhD?

I like facing challenges and bringing out-of-the-box solutions to the table.

And least?

Unexpected delays in my work caused by factors that are out of my control.

What are your future career goals?

I am quite hopeful that I will have a better understanding of climate change and possible mitigation strategies after completing my PhD. I aim to be part of the research community working towards climate change mitigation.

What advice do you have for anyone considering a PhD?

Develop your time management skills and pick up as many research skills as you can. Take advantage of any training courses available to you in order to help with this. ▶

Elena Hayes

Elena did her undergraduate degree in Secondary Science School Teaching at the University of Limerick. A keen horse-rider, her third year was spent on a summer research scholarship in equine science, and this led to a final year project on the analysis of mares' milk protein using Near Infrared Spectroscopy. She is currently in the second year of her PhD, working in association with the VistaMilk SFI Research Centre.

What made you decide to undertake a PhD?

I did not want to continue a career in teaching, and I enjoyed the research part of my degree. I had heard about the Walsh Scholarships Programme and found one that interested me.

What does your research focus on?

I am using two techniques – spectroscopy and chemometrics – to predict milk-processing traits, such as heat stability and rennet coagulation (the addition of enzymes to milk in order to make it clot) time.

> **Do not be afraid to ask for help – it makes everything much easier.**

What do you enjoy most about doing a PhD?

The research is interesting and I enjoy going to conferences and meeting new people.

And least?

The hardest part is being very independent. It can feel lonely sometimes when you are working on your own a lot.

What are your future career goals?

My goal is to end up in a managerial role, possibly in the area of science communication.

What advice do you have for anyone considering a PhD?

Do not be afraid to ask for help – it makes everything much easier. Make sure that you also make time for other activities outside of work. I enjoy horse riding and recently joined the local Fermoy Camogie team. It is very easy to get bogged down in the work, so it's important to have a balance.

Kieran Harrahill

Kieran began his PhD after graduating from University College Dublin with a master's degree in Environmental Policy, following an undergraduate degree in Geography and Politics at the same university. Coming from a farming background, Kieran has always been aware of the role of Teagasc in supporting farmers and undertaking research.

What made you decide to undertake a PhD?

I had a very positive experience throughout my academic career studying topics that greatly interest me, so I wanted to further my studies.

> **By being a part of Teagasc, I have had the ability to speak about my research in lectures and increase people's awareness of the topic.**

Rumia Basu

Rumia studied Chemistry at the University of Delhi, India, before completing a master's degree in Geoinformatics at TERI University, New Delhi, India. After this, she joined the International Water Management Institute (IWMI) as a researcher. She joined the Walsh Scholarship Programme in 2020.

What made you decide to undertake a PhD?

Through my work at IWMI, I realised that it was important for me to choose a career path that gave me a certain amount of freedom in the way that I want to work. Academia and research are sectors that can provide me with this freedom.

I have the freedom to conduct new experiments to make my research sounder, and I have had fun doing education and public engagement activities.

What does your research focus on?

I study soil moisture in Ireland using remote sensing and machine learning techniques.

What do you enjoy most about doing a PhD?

I have the freedom to conduct new experiments to make my research sounder, and I have had fun doing education and public engagement activities through the VistaMilk SFI Research Centre. Doing a PhD also teaches me important lessons in life such as patience and perseverance.

And least?

I get upset and sometimes scared when I do not achieve the expected results (which means repeating the entire experiment). Since there are no known answers, I have had to learn how to deal with such 'failures'. This is something that I had difficulty in accepting. However, I have learned how to handle these moments better – I think!

What are your future career goals?

I envision taking up an academic position in a university so that I get to teach as well as continue doing my research.

What advice do you have for anyone considering a PhD?

A PhD is a very fulfilling journey; however, it can be very difficult at times. I believe that patience and perseverance are key to doing a PhD. It is also a long journey. So, think twice and do a PhD only if you think you would be able to enjoy researching the same topic for a number of years.

What does your research focus on?

My research focuses on the bioeconomy (with BiOrbic SFI Research Centre), aiming to replace products that come from fossil fuels with more sustainable products, for example those that come from plants and agricultural waste. The aim of my research is to identify measures that can assist farmers (namely beef farmers) in becoming involved in the bioeconomy in order to benefit from new income streams.

What do you enjoy most about doing a PhD?

The ability to talk about a research topic that I am very interested in is great. By being a part of Teagasc, I have had the ability to speak about my research in lectures, and this has allowed me to increase people's awareness of the bioeconomy and explain why this is a development that can have benefits not only for the environment, but also for farmers and the viability of agriculture.

And least?

Throughout the PhD process there will be many moments of disappointment – the phrase 'It's a marathon not a sprint' definitely applies.

What are your future career goals?

Moving forward, I want to support the identification of measures that make sure that increasing the sustainability of agriculture does not negatively affect farmers or lead to a resistance to climate policy.

What advice do you have for anyone considering a PhD?

I think it is crucial that you are motivated, goal-driven and have a really keen interest in what you are focusing on. T

Walsh Scholarships Programme

The Teagasc Walsh Scholarships Programme offers fantastic opportunities for postgraduate students wishing to pursue a PhD or an MSc on a topic in agriculture, food, environmental science, agri-food economics, rural development, horticulture and other related disciplines.

Jane Kavanagh, Head of Research Development and Walsh Scholarships, says: "The programme is designed to support the training and professional development of scholars, in association with Irish and international universities and higher education institutes."

Walsh Scholars are predominantly based at a Teagasc research centre, where they are immersed in an active research community for the duration of their studies. They also have access to all the necessary facilities they need to support their research.

"We provide them with a valuable opportunity to develop their research and transferable skills, including their communication through the presentation of their research to various stakeholders," adds Jane.

Every year, Teagasc offers up to 50 new scholarships and each Walsh Scholar receives a stipend of €24,000 per year, of which €6,000 is for their HEI fees.

To find out more about the Walsh Scholarships Programme, visit the 'Opportunities' section of Teagasc's website: www.teagasc.ie.

ACKNOWLEDGEMENTS

We acknowledge the input of the Walsh Scholars' academic supervisors:

Ali Sultan Khan: Dominika Krol and John Finn (Teagasc); Alexandre De Menezes (NUI Galway).
Elena Hayes: Mark Fenelon (Teagasc); Colm O'Donnell and Derek Greene (UCD).
Kieran Harrahill: Áine Macken-Walsh (Teagasc); Eoin O'Neill (UCD).
Rumia Basu: Patrick Tuohy (Teagasc); Eve Daly (NUI Galway).

CONTRIBUTOR

Catriona Boyle
TResearch Editor
Teagasc Head Office, Oak Park Carlow.
catriona.boyle@teagasc.ie

In the weeds

Teagasc researchers have conducted a unique survey determining the level of the grass weed challenge in Ireland.

Grass weeds are becoming an increasing problem in Irish tillage (the preparation of land for growing crops), due to the introduction of practices that enable their rapid growth and their evolving resistance to herbicides.

Resistance to herbicides that control grass weeds has been documented in suspect populations such as wild oats, black-grass and Italian ryegrass since 2019. What researchers didn't know, however, was the extent of the grass weed problem on tillage farms within Ireland, the tactics used to control the weeds and the herbicide resistance status of them.

This information is necessary to facilitate the development of sustainable integrated weed management (IWM) practices so, as part of the Enable Conservation Tillage (ECT) project, a survey of weed management practices and grass weed occurrence was carried out by Teagasc researchers in 2020 and 2021 to address this deficit.

Collecting the data

In 2020, 103 Irish tillage farms were surveyed and then the occurrence of grass weeds was assessed on these farms in both 2020 and 2021. Growers were interviewed using a structured questionnaire to determine their grass weed problems, weed control tactics and IWM components requiring research and advice.

On each farm, one cereal field with critical grass weeds and known management history was selected for grid-based population surveys carried out in mid-summer of each year. For each grid square, a central GPS co-ordinate was logged and a weed score of 0 (absent) to 10 (complete weed cover) was recorded and validated by limited weed counts.

In some farms, more than one field was evaluated due to the incidence of more than one difficult-to-control grass weed type. In farms where mixed difficult-to-control grass weeds were found in the same study fields, each species was assessed separately to obtain individual field-level data.

Over 160 population seed samples from the 103 farms were also collected for glasshouse-based resistance testing with the most commonly used relevant herbicides. The highlights of this survey can be seen on page 17.

Benefits to industry

This survey is the first of its kind, determining the level of grass weed challenges – including herbicide resistance – in Ireland. The results confirm that Ireland is facing an increasing grass weed problem and high levels of herbicide resistance, in black-grass and Italian ryegrass in particular.

EVOLVE, a new Department of Agriculture, Food and the Marine (DAFM)-funded research project, will build on this research, targeting grass weeds and carbon-smart cultivation systems. With a focus on black-grass and Italian ryegrass, the project will analyse the types of resistance evolving and design effective management strategies to cope with the growing grass weed challenge.

The project will also investigate whether native black-grasses have independently evolved resistance or whether they are of UK origin, impacting on control options. Long-term field experiments evaluating a range of IWM strategies will also be established.

The survey outcomes reported here will help to inform the work proposed in the EVOLVE project, in addition to providing up-to-date insights for industry to act on now.

Check out the Summer 2022 issue of *TResearch* to find out how members of the ECT project developed an easy-to-use mobile app to support the collection of data for this project.

FUNDING

The Enable Conservation Tillage (ECT) Project is a European Innovation Partnership (EIP) funded by the Department of Agriculture, Food and the Marine.

ACKNOWLEDGEMENTS

We would like to thank John Mahon (Teagasc) and all project stakeholders for their input.

Survey highlights

Of the 103 farms surveyed:

60% had one critical grass-weed challenge.

21% had two critical grass-weed challenges.

18% had three or more critical grass-weed challenges.

62% Bromes (especially, sterile brome) was the most widespread species, found on 62% of the farms.

56% Wild oats was the second-most widespread species, found on 56% of the farms.

10% Other invasive species were found on 10% of the farms.

22 herbicide-resistant grass-weed populations were identified:

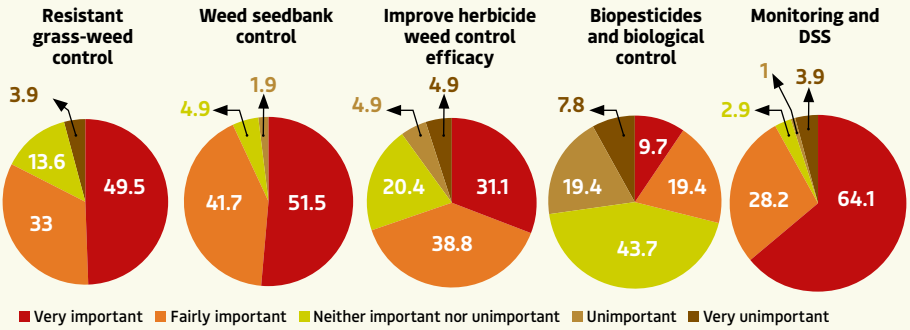
5 bromes.

6 spring wild oats.

5 Italian ryegrass.

6 black-grass.

Growers' responses to integrated weed management research and advice



Growers identified the following as key integrated weed management strategies that need to be developed:

1 Strategies based on decision support system (DSS) tools to optimise weed control.

2 Cultural (non-chemical) control tactics to prevent grass weeds from forming or returning from soil seedbank.

3 Strategies to combat and manage herbicide-resistant grass weeds.

18

The resistant grass weeds were found on 18 of the 103 farms, three of which had two or more resistant grass weeds. Resistance was documented in all arable regions.

The five most common grass weed control tactics used by 103 growers were:

1. Optimum timing of spring herbicide applications.
2. Using glyphosate prior to sowing.
3. Very early application of residual herbicides.
4. Rotating autumn and spring crops.
5. Ploughing.

CONTRIBUTORS

Vijaya Bhaskar A.V.
ECT Project Research Officer
Crop Science Department
Teagasc, Oak Park.
vijaya.bhaskar@teagasc.ie

Dermot Forristal
Principal Research Officer
Crop Science Department
Teagasc, Oak Park.

Susanne Barth
Senior Research Officer
Crop Science Department
Teagasc, Oak Park.

Michael Hennessy
Head of Crops Knowledge Transfer Department
Teagasc, Oak Park.

L-R Fiona McGovern, Eoin Dunne and Edel O'Connor

Measure up

Teagasc researchers are establishing a technique that allows them to rank sheep based on methane output, in order to generate breeding values for methane production.

Photography: Andrew Downes

Over half of Ireland's agricultural greenhouse gas emissions (GHG) are made up of methane – the direct output from the digestive process in ruminants (mammals with multiple stomachs, such as cattle and sheep). To support Ireland's national Climate Action Plan, a better understanding of methane production is needed, in order to develop mitigation strategies.

Since 2019, researchers from Teagasc's Animal and Bioscience Research Department have been comparing methane measurement methods, in order to establish a technique that allows them to rank animals based on methane output. Particular focus is being given to the portable accumulation chambers (PAC) method, which places sheep in a chamber and measures their methane output at a point in time.

Here, Research Officer Fiona McGovern, Senior Research Officer Noirin McHugh, Research Technician Eoin Dunne and Teagasc Walsh Scholar Edel O'Connor (Animal and Bioscience Research Department) discuss the results of their method comparisons and why using PAC is an exciting development for the future of the sheep sector.

What are the methods you're comparing for methane measurement?

Fiona McGovern: We've used portable PAC, sulphur hexafluoride (SF6) and respiration chambers. The main measurement technique we use is the PAC, and the other two were used to validate PAC initially.

Why is establishing a technique to measure methane in sheep production systems important?

Fiona: Our goal is to collect data to generate breeding values for methane production in sheep. We have developed a standard operating procedure for using the PAC in Ireland, and to date, over 3,500 genotyped animals have been measured on farms across the country.

The data will enable the construction of a methane breeding value for sheep in Ireland, which will be incorporated into an Irish sheep genetic index.

What does each method involve?

Edel O'Connor: The PAC is an aluminium box that sheep are placed in for 50 minutes, with methane, oxygen and carbon dioxide measurements taken at three time points. It has the capacity to measure 72 animals per day, and allows us to identify high and low methane-emitting sheep in the flock.

Respiration chambers are considered the gold standard of methane measurement as they're very accurate. They are airtight cabins that can measure an animal's methane production over a period of two to four days. Unlike PAC chambers, however, they have limited capacity.

Eoin Dunne: Our third method, the SF6 tracer, releases a known rate of SF6 gas from a tube in the animal's stomach, and samples of exhaled breath are collected in an evacuated canister over a 24-hour measurement period. This method allows methane production to be measured from sheep in their natural environment.

What are some of the key findings from your work so far?

Edel: We have found that there is a good relationship between methane production measured using both the PAC and the respiration chamber. This means the animals are likely to be ranked the same, irrespective of the measurement technique used.

Teagasc is currently the only group in Ireland looking directly at methane emissions from sheep systems

This result highlights the suitability of the PAC as a measurement technique that will not only allow for a higher throughput of animals, but also allow animals' methane production to be measured in their natural environment.

Have any of the results surprised you?

Noirin McHugh: Edel is conducting work to determine how methane production differs depending on life stage and stage of production. What we've seen so far is that about 30% of the differences in methane output between two animals is purely down to genetics and not related to diet type, breed or life stage.

This is great news as it means we can make rapid progress in identifying animals with good levels of animal performance but lower levels of methane emissions.

Equipment used to measure methane outputs

Is there anything novel about the work you're doing?

Edel: Our use of PAC to measure methane production is quite unique to our geography – across the world, New Zealand and Australia are the two main countries using PAC in this way. Like New Zealand, we will develop our own genetic breeding values, making us one of the first countries in the northern hemisphere to achieve this.

Noirin: In Ireland, our work is unique because Teagasc is currently the only group looking directly at methane emissions from sheep systems. As such, we work very closely with Sheep Ireland – the company responsible for the national genetic evaluations in Ireland – to make sure that our research can be implemented quickly into Ireland's breeding indexes.

How have farmers reacted to your work?

Eoin: I have been measuring animals using the PAC on farms over the past few months, and it has been a great experience. Farmers are very accommodating and enthusiastic about the results.

This is a novel line of work in terms of the sheep sector, which has brought about challenges regarding the mentality of some farmers who see it as unnecessary, but our goal is to make farmers aware of our current situation regarding greenhouse gas emissions and to help them develop mitigation strategies.

What are the benefits of this project?

Noirin: This project has huge implications for the Irish sheep industry. If we can show that we are able to select animals with lower levels of methane emissions while still maintaining high levels of production, we can help to reduce the carbon footprint of the industry.

What's next for your research?

Fiona: We need to extend research into strategies that improve efficiency and reduce farm GHG emissions. Data we obtain can feed into our national GHG inventories and determine the impact of pasture type and quality on methane output in sheep.

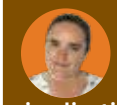
Noirin: We will also look to implement our research findings into the national genetic evaluations. Doing this will enable Irish sheep farmers to select animals with lower levels of methane emissions that will also help to increase flock performance and profitability. T

In good company

What do you find most interesting about this type of research?

Edel: For me, the most interesting part of this research is seeing how an animal's methane production changes throughout their production cycle and at different life stages.

Fiona: This research is innovative and of national importance, with major impacts for ruminant animal production systems – especially sheep. Results generated will facilitate management decisions and promote profitability on sheep farms nationally.



Nóirín: This is groundbreaking research and has major implications for the Irish sheep industry – our results can help to increase its long-term viability.

Eoin: What I find most interesting is how progressive this field of work has become in Ireland in recent years. We are advancing at a very quick rate, and it is becoming more accepted and appreciated by farmers across Ireland.

Enhancing the multi-actor approach

Teagasc social scientists have produced evaluation and impact assessment tools to support innovation-driven collaboration between actors.

The multi-actor approach refers to a collaborative process where different actors (researchers, farmers, advisors, etc.) combine their knowledges (scientific, practical, organisational, etc.) for innovation.

Because it involves actors from different disciplines and sectors, multi-actor interactive innovation is essential in supporting systems-based approaches, in which the decisions and actions made in one area will affect another. This is particularly true for advancing sustainability, as addressing transdisciplinary problems requires transdisciplinary solutions.

Involving end-users such as farmers and advisors in the approach is necessary to produce practice-ready solutions and opportunities that have a high Societal Readiness Level – those considered ready to be taken up by end-users.

At EU-level, multi-actor interactive innovation is widely known as an approach capable of addressing environmental, social and economic challenges to reaching sustainability goals, as well as achieving innovation for greater wellbeing and prosperity. In agriculture, relevant actors seeking to participate in EU-funding schemes are increasingly being called upon to implement the multi-actor interactive innovation model within their funded initiatives.

To support actors in practically enhancing their multi-actor interactive innovation initiatives, Teagasc social scientists have led the co-design of a toolbox to evaluate and assess the impacts of interactive innovation, as part of the LIAISON Horizon 2020 project.

Evaluating innovation processes

The challenge of evaluating innovation processes lies in understanding the interplay of actors (and their knowledge) and multi-actor group dynamics.

Áine Macken-Walsh, Sociologist and member of the LIAISON project, explains: "Our work differs from classical, quantitative evaluation approaches where outcomes of a process or project are assessed using pre-determined, measurable indicators.

"Instead, our aim is to assess so-called 'soft' outcomes and impacts of interactive innovation processes using qualitative techniques. These include outcomes like empowerment, changed perspectives, trust building and relationship improvements."

It is critically important for evaluation and impact assessment techniques to be used repeatedly throughout an interactive innovation process, so that the process can be improved and enhanced. The principal objective of the interactive innovation process is to support inter-actor dynamics, so how an initiative succeeds in creatively

Figure 1. The five scenarios of multi-actor work

alvarez /iStockphoto.com

Advancing sustainability requires actors from different disciplines and sectors to work together

combining diverse knowledge must be evidence-based and verifiable.

"It is important for projects and evaluators to capture the driving forces that shape and fuel the interactive innovation process," says Áine, "and the nature of the impacts it delivers.

"Initiatives must also demonstrate how effectively the interactive innovation process is practically implemented (to funders who increasingly demand it), and capture how various forms of value and positive impacts are attributable to the process."

Practical tools to enhance interactive innovation

The LIAISON team – involving Teagasc, the Research Institute of Organic Agriculture in Austria, The Technical University of Madrid, Spain and and European think tank Bruges Group – produced a toolbox containing 37 'step-by-step' tools. These were informed by social science knowledge on human behaviour, culture, networking, governance, power, gender and other theoretical fields.

Of these 37 tools, Teagasc was responsible for producing 27. They are qualitative- and process-orientated, and are inspired by two main methodological approaches: Developmental Evaluation and Social Impact Management Planning.

"Developmental Evaluation not only charts incrementally how and why different impacts occur throughout the interactive innovation process, but it generates and tests strategies to alter the course of innovation processes with a view to enhancing impacts," explains Áine.

"Meanwhile, Social Impact Management Planning is a management tool for addressing social impacts during the implementation of development projects, supporting adaptation of actions to enhance positive impacts and prevent or ameliorate negative impacts.

"These assessment approaches respond to the relational dynamics of interactive innovation, unexpected impacts and the need to adhere to the EU's framework on responsible research and innovation."

Áine and her colleagues at Teagasc co-designed practice-ready evaluation and impact assessment tools, and piloted them in the field using real multi-actor interactive innovation projects. This co-design process, itself a process of multi-actor innovation, enhances the Societal Readiness Level of the tools.

Once finalised, the tools were launched. So far, they have been used by several EU-funded projects, including Horizon 2020, Horizon Europe and EIP-Agri Operational Groups. The tools have been used in Teagasc initiatives and projects funded by the The Department of Agriculture, Food and the Marine's Research Stimulus Fund. A Teagasc Walsh Scholar has also piloted the tools in a Horizon 2020 project, to capture learnings specifically for Teagasc Advisory Services. T

The LIAISON toolbox in practice

The evaluation and impact assessment tools are presented in a practitioner handbook, where end-users are first invited to examine their multi-actor interactive innovation process. A whiteboard animation is used to increase end-users' attentiveness to important features of the multi-actor innovation process, so that these features may be focused on in the evaluation and impact assessment.

Furthermore, a range of identifiers are presented to support end-users' selection of appropriate tools. The tools are organised around two axes:

1. **The five distinctive scenarios and challenges that characterise multi-actor interactive work (see Figure 1).**
2. **Practical considerations, such as when to implement the initiative, group size, level of technical complexity, time needed to implement and resources required.**

This structure aids end-users in navigating and selecting appropriate tools for their particular evaluation and impact assessment needs and circumstances.

CONTRIBUTORS

Áine Macken-Walsh
Department of Social and Geographical Sciences
Rural Economy Development Programme, Athenry.
aine.mackenwalsh@teagasc.ie

Martin Javornicky
Department of Social and Geographical Sciences
Rural Economy Development Programme, Athenry.

Anita Naughton
Department of Social and Geographical Sciences
Rural Economy Development Programme, Athenry.

Food safety in dairy environments

Researchers at Teagasc and the University of Veterinary Medicine Vienna, Austria, are identifying the bacteria present in dairy processing environments to evaluate their impact on the foodborne pathogen *Listeria monocytogenes*.

Food processing facilities are required to follow many regulations to provide food safety assurance. However, the food processing environment in general is not sterile. In fact, the presence of specific in-house microorganisms are sometimes desired. A good example of this is the cheese production environment. The composition of the microbiome (the community of microorganisms) present in the immediate environment can contribute to the desired characteristics of the product, and even allow its correlation to a production region.

Nonetheless, bacterial communities may harbour pathogens that can compromise food safety. That is why Teagasc and the University of Veterinary Medicine Vienna, Austria, have developed the LmRNA project, focused on collecting samples from dairy processing environments and characterising the microorganisms present, in order to prevent the presence of harmful pathogens.

Persistent bacteria

Biofilms are the natural state of bacteria in the environment. These bacterial communities are composed of microorganisms embedded in a protective self-produced matrix that facilitates their attachment to a surface.

After entering a food processing environment, bacteria initiate biofilm formation with a reversible attachment to a surface. With time, these bacteria produce exo-polymeric substances (EPS) – of which carbohydrates, proteins and extracellular DNA are the main components – which give the attachment an irreversible nature that can only be lost if direct mechanical and chemical action is performed.

Given time, biofilms grow and shed bacterial cells and even clumps of cells embedded in EPS. This causes the spread of the bacteria and may became the source of recurrent contamination. The biofilm EPS acts as a barrier for the diffusion of antimicrobials, leading to the protection of the enclosed cells. Moreover, the actual chemical nature of the EPS often leads to the inactivation of sanitiser and cleaning agents used in the food industry.

The LmRNA project uses a metagenomics approach, which allows the researchers to look at the composition of the microbiome of the environment, the most prevalent microorganisms present in the sampled environments and the interactions between the microorganisms present in biofilms. It can also be used to decide on the most relevant microorganism for further study. In parallel with the compositional analysis, culture-based methods are used to isolate the live bacteria from these environments.

A combination of these approaches is currently being used to create mock communities of microorganisms in the laboratory that mimic what is found in the dairy processing environment.

Antonio Lourenco, Teagasc

The presence of foodborne pathogens in dairy products is a result of contamination from biofilms present in the food processing environment

6

During the first six months of 2022 alone, the *Listeria monocytogenes* pathogen caused at least six recalls issued by the Food Safety Authority of Ireland.

Protecting public health

Despite the generalised ability for bacteria to form biofilms, not all bacteria are equally capable of it, mostly due to the amount and specific composition of EPS produced. These differences can be seen not only between different species of bacteria, but even among different isolates of the same species.

In a food processing environment however, the biofilms found are of a multi-species nature. This generates a close interaction among the different microorganisms present and can lead to collaborative interactions, where a weak biofilm former's presence is aided by the presence of a strong biofilm former.

The opposite may also occur. Through their natural metabolism, some bacteria will produce compounds that inhibit the growth of other bacteria, creating a hostile environment for others.

Listeria monocytogenes is a pathogen of significant public health concern because, despite its low infection rate, it has a much higher mortality rate when compared to other foodborne pathogens. The researchers are carrying out biofilm formation of the *L. monocytogenes* in the laboratory. They are doing so under conditions relevant to the dairy industry, including low temperatures, relevant growth media, flow regimes and relevant surface materials such as stainless steel. The role of other microorganisms collected from the dairy environment is also being further investigated to determine their impact on the gene expression of *L. monocytogenes*.

Ultimately, the project team aims to facilitate the identification of molecular targets for antimicrobials, leading to improvement in strategies to prevent harmful pathogen persistence in the dairy industry. T

FUNDING

Antonio Lourenco received funding from the Research Leaders 2025 programme (co-funded by Teagasc and the European Union's Horizon 2020 research and innovation programme), under the Marie Skłodowska-Curie grant agreement number 754380.

CONTRIBUTORS

Antonio Lourenco
Research Leaders 2025 and Marie Skłodowska-Curie Fellow Teagasc Food Research Centre, Moorepark, Co. Cork.
antonio.lourenco@teagasc.ie

Kaye Burgess
Senior Research Officer Teagasc Food Research Centre, Ashtown, Co. Dublin.

Martin Wagner
Institute for Food Safety, Food Technology and Veterinary Public Health University of Veterinary Medicine Vienna, Austria.

Olivia McAuliffe
Principal Research Officer Teagasc Food Research Centre, Moorepark, Co. Cork.

White clover:

a sustainable alternative to nitrogen

Introducing white clover into perennial ryegrass swards can sustainably increase milk production while maintaining grass production, reducing the need for inorganic nitrogen.

Perennial ryegrass (PRG) grass-based systems are highly efficient and low cost, but are dependent on high levels of nitrogen fertiliser. In recent years, there has been renewed interest in the inclusion of white clover in PRG-based production systems, in order to reduce the environmental impacts and input costs of inorganic nitrogen use.

White clover is a valuable natural resource that can be included into PRG-based systems to increase grass and animal production. It is the predominant legume species incorporated into grass swards in temperate regions and has a lot of agronomical advantages.

White clover possesses the ability to convert atmospheric nitrogen into a plant usable form (i.e. nitrate) to facilitate PRG growth and production. It is also a nutritionally superior feed than PRG alone, as it promotes higher dry matter intakes due to its lower neutral detergent fibre levels. This in turn can lead to higher milk production per cow.

In order to avail of these potential production benefits, it has been suggested that white clover needs to be established within the sward at a minimum rate of 20%. To test this, researchers from Teagasc established an experiment at Clonakilty Agricultural College in Clonakilty, County Cork, from February 2019 to November 2021. ▶

Martina Berg /stock.adobe.com

The experiment

The researchers examined both perennial ryegrass (PRG)-only and PRG-white clover (WC) swards at two fertiliser rates – 150kg nitrogen (N)/ha and 250kg N/ha. This resulted in four separate grazing treatments:

PRG-only x 150
A PRG-only sward receiving 150kg N/ha.

PRG-only x 250
A PRG-only sward receiving 250kg N/ha.

PRG-WC x 150
A PRG-white clover sward receiving 150kg N/ha.

PRG-WC x 250
A PRG-WC sward receiving 250kg N/ha.

A separate farmlet (small farm) of 10.8ha consisting of 20 paddocks was created for each treatment:

30
There were 30 cows per treatment.

2.75
Each dairy grazing platform was stocked at 2.75 cows per ha.

4
Four breeds of cows were used and balanced amongst each treatment.

Within breed, cows were assigned to treatment based on parity, calving date, pre-experimental milk yield and economic breeding index.

Cows had a mean calving date of 8 February.

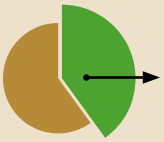
284 days
The average lactation length of the cows was 284 days.

The cows were on a silage-only diet over the winter dry period (December and January).

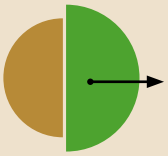
Treatments were rotationally grazed from early February, whereby cows grazed both day and night as they calved (weather permitting) up to mid-November each year.

4cm
The target post-grazing sward height was 4cm.

Nitrogen fertiliser applications were similar for all treatments in late January, mid-March and April. Thereafter...



40%
...the 150 kg N/ha treatments received 40% of the 250 kg N/ha treatment rate for each subsequent rotation...



50%
...and received 50% for the final rotation.

Inorganic phosphorus and potassium were applied across all swards based on yearly soil test results. Sulphur was also applied during the main growing season.

1x week
Each farmlet was assessed weekly to monitor average farm cover treatment using the online application PastureBase Ireland.

600kg
Cows were supplemented with just under 600kg of concentrate per year throughout the lactation, and if deficits occurred within individual treatments, silage was supplemented.

White clover content was measured before each grazing in paddocks on a dry matter basis. On average, over the three years of the experiment it was 18% for PRG-WC x 150 compared to 15.4% for PRG-WC x 250 treatments.

The impact of white clover on grass

The inclusion of white clover in PRG grass-based systems increased milk production. It was also observed that higher milk solids production arose due to higher overall milk production rather than higher milk fat and protein content.

Cows grazing PRG-WC swards had a 6% higher daily milk solids yield, which resulted in a 29kg difference in cumulative lactation milk solids yield. This is a substantial increase in milk solids, particularly at the lower nitrogen input level, that is both critical for the environment and economically important for the farmer – two major issues affecting the industry at present.

As land availability and environmental constraints are two of the main limiting factors affecting increasing production on farms, white clover inclusion into PRG swards is a key grassland strategy that should be incorporated to overcome this challenge. Therefore, it should be promoted that even at the relatively low white clover contents witnessed in this study, white clover can make a positive impact both in terms of grass and milk production.

When the nitrogen inputs were reduced by 100kg/ha and white clover was included in its place, there was a reduction in total grass growth of 0.5 tonnes *vs.* 1.5 tonnes when nitrogen inputs were reduced by 100 kg/ha on PRG-only swards. Increasing the white clover level in the swards should increase the grass growth further and reduce the gap of total grass grown between the nitrogen treatments. This can also help to insulate farmers from dramatic price fluxes in a volatile market.

These findings should reassure both farmers and industry in promoting the inclusion of white clover in swards, meeting the long-term goal to convert whole farm grazing systems from PRG-only swards to PRG-WC swards. T

CONTRIBUTORS

Áine Murray
PhD Walsh Scholar
Teagasc Animal & Grassland
Research and Innovation Centre, Moorepark, Co. Cork.

Brian McCarthy
Research Officer
Teagasc Animal & Grassland
Research and Innovation Centre, Moorepark, Co. Cork.
brian.mccarthy@teagasc.ie

Getting to know

Cristina Botinestean

Food Technologist **Cristina Botinestean** grew up in Romania but now lives in Ireland and works at the Teagasc Food Research Centre. Here, we find out where her passion for food science comes from, and why she chose to work at Teagasc in order to carry it out.

When did your love for science and food begin?
I was a curious child, eager to explore and always wanting to understand how things worked. My first experience in a new product development and food sensory science 'lab' was in my parents' kitchen, adjusting my mother's recipes and engaging in food science experiments.

How did you end up working at Teagasc?
I moved to Vienna to complete my PhD in Food Engineering, and then joined Teagasc as a post-doctoral researcher. Following that, I became a research officer, and then I earned a permanent position. I chose to stay because Teagasc encourages a multicultural working environment; being part of the Teagasc family is one of my proudest career accomplishments.

Why did you choose to settle in Ireland?
After living in Vienna I gained more confidence and the opportunity at Teagasc came at the right time. There are many things I like about Ireland, from the spectacular landscapes to Irish people who are very kind. I recently received my Irish citizenship and Ireland feels like home now.

Why is your current research area of interest to you?
Leading food research and industry projects (particularly in the areas of Meat Science and Sensory Science) allows me to successfully combine the skills and knowledge I've gained throughout my career. Having previous experience working in the industry, academia and research sectors allows me to offer a significant contribution to Teagasc's impressive research programme.

What does a typical weekend look like for you?
I enjoy watching sports events, playing chess and spending time with my family virtually. I'm very active and sociable – I love long walks on the beach, meeting my friends and playing tennis. T

CONTACT
cristina.botinestean@teagasc.ie

Inside industry collaboration

Teagasc's Food Chemistry and Technology department works closely with the food and dairy industry, providing key players with research that underpins their success. Here, Head of Food Chemistry and Technology John Tobin provides an insight into Teagasc's motivations for working with industry and the benefits it offers.

Photography: Fergal O'Gorman

The Food Chemistry and Technology department is one of the largest research departments in Teagasc. It encompasses a diverse team of permanent and contract researchers and technical staff, in addition to Walsh Scholars and hosted students.

The department's mission is to provide the food industry with science and research that supports and underpins its success. Leading the department is Head of Food Chemistry and Technology John Tobin, who effectively

Pictured: John Tobin in Teagasc's in-house designed filtration plant, one of the many facilities that industry benefits from.

manages the resources assigned to the department to ensure that a cohesive vision is in place regarding its research activities.

John joined the department – and Teagasc – in 2006 as a Walsh Scholar. He then took up a brief contract position in the organisation, before moving to an industry role with leading food company Danone. He re-joined Teagasc in 2015 as a permanent senior researcher in dairy science and process engineering. In 2016, he was appointed Head of the Food Chemistry and Technology department.

John, what are your motivations for engaging with industry?

Supporting the food industry in Ireland – in particular the dairy sector and nutritional formulators – is our remit. With our subsidiary Moorepark Technology Limited we offer a range of services, from advanced analytical perspectives through to pilot plant services. We also execute contract and collaborative research projects to meet specific industry collaborator needs, which we approach both proactively and reactively.

What do you think attracts industry to engage with Teagasc?

Our model of industry engagement is a major factor. Unlike higher education institutions, Teagasc is structured to deliver research on a full-time basis. Companies favour the fact that we are already carrying out applied research activities and publishing papers that will support their work, and they often reach out to us directly to partner up or learn more.

We also offer access to process and analytical infrastructure, including a state-of-the-art commercial pilot plant. Companies use our bespoke food factory pilot to carry out services they wouldn't want to do at a commercial factory, such as testing products and process conditions.

Because we operate on a large research campus, those visiting also have the opportunity to interact with researchers from related departments, such as the Food Safety department and the Food Quality and Sensory Science department.

What are the benefits of working with industry?

Working with industry ensures that our core research themes are in line with and relevant to industry needs. We also benefit from the connections made. Many of our skilled researchers have gone on to take up roles both with our industry collaborators and the wider Irish food sector, generating for us a strong network of contacts that we're able to draw on.

What are the challenges of working with industry?

The management of confidentiality and protection of intellectual property from all parties involved is always at the fore when negotiating a new research project. Luckily, we have the research support and the Technology Transfer Office available to ensure that any potential challenges or roadblocks are both identified and addressed at the earliest point.

Another challenge is managing industry expectations, as things don't always work out as intended. Research can take unexpected turns and the outcome may not always be what the industry partner is hoping for. But we always share our learnings and ensure the delivery of the agreed project brief.

How can researchers protect their own interests when it comes to intellectual property?

Consider carefully the ownership of background intellectual property and agree with the industry partner how any outputs from the project will be protected and transferred to the industry collaborator. This in itself will depend on whether the agreement is contract or collaborative in nature, so familiarise yourself with the details and seek support from those with more experience if needed.

What are the considerations researchers should make before embarking on industry collaboration?

Understandably, industry place a lot of emphasis on the need to successfully deliver a project. For researchers, this means there should be a careful review of the allocated budget and resource before agreeing to partner up.

What are the factors that contribute to long-lasting, successful and impactful collaborations with industry?

Good communication is essential, especially if you want to start a project in the right way. Ensure there is clarity and vision regarding what each partner will deliver and be transparent.

As mentioned above, you need to have a clear idea of budgets and timelines – particularly when the project will start. At Teagasc, we set ourselves a high standard to always deliver projects on time and within budget, which is key to maintaining active industry engagement.

Once the project is underway, keep your industry partner updated on progress regularly, and be willing to disseminate results as and when needed.

How successful would you say the Food Chemistry and Technology department's collaboration with industry has been over the years?

It has been very successful. We have had lots of return business and successive research projects with many clients, which is indicative of the positive working relationships we have been able to build.

Lots of the most impactful work we do never gets published due to confidentiality clauses, but we have been instrumental in the development of new process innovations, the licensing of intellectual property and, in one instance, establishing a new dairy factory in an emerging market.

Our industry interactions have led to millions of euros worth of investments into Teagasc's campus. Our research is well respected, so much so that many companies have chosen to establish a research base at our Food Innovation Hub. We can be proud that our campus is a place that industry wants to be and we're an organisation that they want to work with. T

Up close and personal

What's your favourite animal?
Irish dairy cow. Based on my affiliation with Teagasc, of course.

If you hadn't ended up in research, what other job would you have wanted to give a go?
I would have done a trade, I reckon. Perhaps some sort of fitter or a mechanic.

What are you most proud of professionally?
Being appointed to my current role as Head of the Food Chemistry and Technology department within two years of joining Teagasc as a permanent researcher.

One step ahead:

finding alternative ways to treat bovine mastitis

Growing pathogen resistance to antibiotics has led researchers to explore the use of probiotic and postbiotic formulations in treating mastitis in dairy cattle.

Mastitis – the infection and inflammation of the udder – is the most prevalent and economically significant disease in dairy cattle. Farms with cattle suffering from this disease are impacted by depleted milk production, discarded milk, premature culling and treatment costs.

The causative agents of mastitis are usually bacterial pathogens (disease-causing bacteria) such as *Staphylococcus aureus*, *Streptococcus uberis*, *Streptococcus dysgalactiae* and *Escherichia coli*. As a result, cows suffering from mastitis typically have a high somatic cell count (SCC) in their milk.

Currently, the treatment options for bovine mastitis involve antibiotics. However, pathogens often develop resistance to antibiotics, which frequently results in treatment failure. In light of this, researchers at Teagasc and APC Microbiome Ireland have been investigating alternative ways to treat bovine mastitis.

Pathogens often develop resistance to antibiotics, which frequently results in treatment failure

Dajra, Pongpreecha Malaluang / shutterstock.com

Developing probiotic formulations

One alternative option to treat bovine mastitis is to use beneficial bacteria (some of which are classed as probiotics) to kill mastitis-causing bacteria. Previous field trials showed that bacteria such as *Lactococcus lactis* DPC3147 can produce antimicrobial peptides called bacteriocins, which kill mastitis-causing pathogens.

As a result, this bacterial strain was used in two further field trials to develop alternative therapeutic options to antibiotics. The researchers then tested these new therapeutics to see if they performed better, worse than or on par with antibiotics used for treating bovine mastitis.

Harsh Mathur, Research Officer, Teagasc, is one of the researchers who conducted the field trials. He says: "In the first of these trials, we developed a mineral oil-based emulsion formulation that included live cells of *L. lactis* DPC3147, and tested the formulation's effectiveness directly against antibiotics."

The medicines were injected into different udders affected by mastitis, and then the results were compared.

"We found that the oil-based formulation stimulated the cow's natural immune response to fight off the infection and performed just as well as antibiotics in curing mastitis," says Harsh. "Its cure rate was equivalent to antibiotics, and it was just as effective at reducing SCC within one week of infusion."

Cattle suffering from mastitis produce less milk

€19,504

One study estimated that mastitis results in a farm profit decrease of €19,504 for the average 40-hectare farm.

Live *vs.* dead cells

The results from the first field trial prompted the researchers to further develop the oil-based formulation, in order to understand how it works in stimulating the cow's immune response.

"In our second field trial, we aimed to find out if these probiotic cells had to be alive or if heat-killed cells (known as postbiotics) of the strain were capable of stimulating the cow's immune response to clear the infection," says Harsh.

"We developed an identical formulation to the above, but with heat-killed *L. lactis* DPC3147 cells. Both formulations performed equally well in stimulating the cow's immune response to fight off and clear the infection."

The fact that the heat-killed cells performed on par with the live cells was encouraging, as it counteracts the need for preparing formulations containing freshly growing live probiotic cells.

Catherine Stanton, Senior Principal Research Officer at Teagasc and project team member, says: "By including heat-killed cells of the *L. lactis* DPC3147 strain in oil-based formulations, we have circumvented issues relating to the shelf-life of these products. This will potentially give farmers additional options when it comes to storing these formulations, ready to use when required."

The researchers are currently preparing for future field trials where they hope to understand the mechanisms of the oil-based formulations.

"We hope that by gathering more information on these alternative formulations, we will give farmers confidence to view them as realistic options to antibiotics when treating bovine mastitis in the herd," concludes Catherine. T

ACKNOWLEDGEMENTS

We would like to thank Colin Hill (APC Microbiome Ireland) and Jim Flynn (Teagasc) for their contribution to this research.

FUNDING

This work was funded by the Science Foundation of Ireland (SFI) Centre for Science, Engineering and Technology (APC grant number SFI/12/RC/2273_P2) and VistaMilk Work Package TP9.

Research in Catherine Stanton, Paul Ross and Colin Hill's laboratories is supported by SFI and APC Microbiome Ireland.

CONTRIBUTORS

Harsh Mathur
Research Officer
Teagasc Food Research Centre,
Moorepark, Co. Cork.

Kevin Linehan
PhD student
Teagasc Food Research Centre;
APC Microbiome Ireland.

Paul Ross
Director of APC Microbiome Ireland
University College Cork.

Catherine Stanton
Senior Principal Research Officer
Teagasc Food Research Centre;
APC Microbiome Ireland.
catherine.stanton@teagasc.ie

Health help from kelp

A common native Irish kelp species could offer a promising preventative remedy for high blood pressure.

Health issues that can lead to heart disease, such as diabetes, inflammation and high blood pressure (hypertension) are a growing global concern. Data collected over the past 20 years found the number of adults with hypertension had doubled to approximately 26% of the global adult population in 2019. This number is set to rise to 29% of the global population by 2025, which will affect 1.56 billion people.

Seaweed is considered a potential resource of bioactive compounds that may be used to treat such ailments. It has a long history of use as both food and medicine, especially in Asian cultures. In recent times, there has been a growing interest across the world in the use of seaweed ingredients and bioactive compounds in pharmaceutical and nutraceutical products.

Through their ALGIPRO project, researchers from Teagasc and the Cawthron Institute, New Zealand, have been exploring the bioactive compounds of kelp – the common name for one order of brown seaweeds known as *Laminariales* – and their ability to treat health conditions.

Using a native Irish resource to improve health

One particular ailment that seaweed bioactive compounds may impact is hypertension caused by the enzyme Angiotensin Converting Enzyme 1 (ACE-1), which causes the narrowing of blood vessels.

Hypertension is usually treated using drugs, but there are side effects associated with them. This has prompted the pursuit of natural remedies that may prevent the development of high blood pressure – and kelp is a known source of several bioactives with potential suitability.

Diane Purcell-Meyerink, Marie Skłodowska-Curie Fellow at Teagasc and ALGIPRO project member, says: "We have explored the generation of bioactive peptides containing hydrolysates (a protein product consisting of small proteins and peptides made using enzymes), which may exert a positive effect in humans due to their health-promoting properties.

"We chose to focus our investigation on the potential of the native Irish kelp species *Laminaria digitata*, called 'oarweed' in English, or in Irish 'Leathrach' or 'Coirrleach'."

Leathrach is a common kelp found in low-level waters around the Irish, North European and eastern North American coast and can grow up to 2.5 metres long and 60 centimetres wide. Surveys of the Irish coast have found Leathrach around the entire Irish coastline, with 56% of the coast from Donegal to Cork having

jif06/shutterstock.com

Leathrach in different forms, from raw seaweed to final protein powder

some level of kelp coverage.

"Despite its accessibility," Diane adds, "it is a relatively untapped kelp species."

The creation of a promising product

To isolate the proteins from Leathrach, the researchers broke down the cell wall using enzymes. Hydrolysis and filtration treatments resulted in a protein powder, and the protein content of this powder was found to be 24%. In comparison, the whole raw seaweed was found to have 15% protein.

Protein hydrolysates within the kelp where then tested for bioactivities, specifically their ability to inhibit ACE-1.

"When compared to a popular commercial ACE-1 inhibitory drug, ACE-1 was inhibited by 75% by the protein hydrolysate," says Diane. "In addition, the total amino acid content of the hydrolysate was 32% essential amino acids – an excellent profile. This is significant as essential amino acids can act as important dietary supplements."

1.28 billion

people are estimated to have had hypertension in 2019.

Thanks to the researchers' study, a seaweed protein powder with ACE-1 inhibitory bioactivities has been extracted from Leathrach. This powder has potential applications as a protein source for functional food use, and further work will be done to assess its antihypertensive activity. If suitable, it could be a key product in helping to control blood pressure. T

ACKNOWLEDGEMENTS

We acknowledge Karen Hussey (Teagasc) for her assistance in the sample analysis for this project.

FUNDING

Diane Purcell-Meyerink has received funding from the Research Leaders 2025 programme (co-funded by Teagasc and the European Union's Horizon 2020 research and innovation programme), under the Marie Skłodowska-Curie grant agreement number 754380.

CONTRIBUTORS

Diane Purcell-Meyerink
Research Leaders 2025 and Marie Skłodowska-Curie Fellow
Teagasc Food Research Centre,
Ashtown, Co. Dublin.
diane.purcellmeyerink@teagasc.ie

Maria Hayes
Senior Research Officer
Teagasc Food Research Centre,
Ashtown, Co. Dublin.

Mike Packer
Senior Research Scientist
Algal Biotechnology Group
Cawthron Institute, New Zealand.

"Seaweed is considered a potential resource of bioactive compounds that may be used to treat ailments such as hypertension and diabetes."

Leathrach is a very common kelp found in low-level waters around the Irish, North European and eastern North American coast

Experts from Teagasc have been exploring ways to help beef farms meet both economic and environmental targets. Having shared their findings at BEEF2022 – Teagasc's Beef Open Day – here, they recap the key technical messages beef farmers need to know.

Supporting sustainable beef farming

Beef production in Ireland has an array of different systems. Farms often move between systems, depending on the market conditions, from one year to the next. Which beef system suits a farm or farmer – and the intensity at which it is farmed – depends on a number of different factors.

One of the biggest influences on choice of beef system is labour availability. Most beef farmers have full-time off-farm employment and can only commit a certain amount of hours each week to farming. This limits the number of animals carried on that farm. It is worth noting, however, that where animal-handling facilities are of a high standard and pasture infrastructure is well developed, labour shortfalls can be mitigated to some extent.

Land type characteristics such as soil type, soil fertility, drainage capacity and level of fragmentation further influence the most suitable beef system for a farm and the stocking density that can be managed from a forage-based diet. Ultimately, the quantity of grass a farm can grow and graze efficiently in a year dictates the number of cattle that a farm should carry.

Analysis at BEEF2022 – Teagasc's Beef Open Day – evaluated the financial and greenhouse gas emissions (GHG) performance of four suckler systems. It considered the perspective of beef farms where either labour is limited and the objective is to maximise performance per animal, or labour is more freely available and the objective is to maximise performance per hectare.

The results indicated that profitability per head for spring-born suckler progeny was greatest for grass-based finishing systems, either at the end of the second grazing season (19 to 21 months of age) or during the third grazing season (25 to 28 months of age).

In comparison, profitability per hectare was greatest for the earlier slaughter scenario. On top of that, GHG emissions per kilogram of beef output were lower.

Setting performance targets

Due to the considerably lower comparative cost of grazed grass as a feedstuff, beef production systems in Ireland are predominantly grass-based and 'designed' to optimise the seasonal supply of pasture. A key objective is to increase the contribution of high-digestibility grazed grass to the lifetime intake of feed, through as long a grazing season as possible, while simultaneously achieving high

The ability of an animal to meet production targets is a function of genetic merit, health, nutrition and management.

Mark Moore /Teagasc

individual-animal performance.

Providing sufficient grass silage of appropriate digestibility for the indoor winter period is also a crucial component of grassland management and feed self-sufficiency in beef production systems. Additionally, there are a range of animal performance targets that can broadly be categorised as those pertaining specifically to suckler cows and beef progeny.

At BEEF2022, the importance of meeting these targets from an economic and GHG perspective were evaluated. Notably, age at first calving and length of the grazing season were found to be key determinants of profitability and GHG emissions intensity.

Critical management practices

The ability of an animal to meet the production targets outlined above is a function of genetic merit, health, nutrition and management. In terms of animal performance targets, breed and genetics creates the potential, but it is management that primarily allows that potential to be achieved.

Genetic indexes are an important tool that have allowed Irish cattle breeders to make more informed breeding decisions and improve farm efficiency. For example, the commercial beef value (CBV) is a genetic index for 'non-breeding' beef cattle, focused on identifying animals with superior carcass traits and feed efficiency. Based on analysis from Teagasc's Grange dairy-beef research herd over the last three years, five-star CBV beef x dairy steers produced a 22kg heavier carcass at a younger slaughter age (four days) compared to one-star animals, when reared on an 'intensive' grass-based production system.

The ability of beef farms to grow and utilise grass is fundamental to the economic, environmental and social sustainability of beef production systems. Even allowing for differences in local climate and soil types, large variations in annual grass production exists between beef farms, and thus highlights an opportunity to increase grassland efficiency through management.

Clover also has an important role in further reducing the cost of grazing swards, given its ability to convert atmospheric nitrogen, thereby improving farm-gate nitrogen balance and reducing costs.

Finally, herd health plays an important role in performance on beef cattle farms and is crucial to fertility, productivity and profitability. A herd health plan that includes bio-security, vaccinations and the culling of 'carrier' animals, drawn up in consultation with the farm's veterinary practitioner, will offer the best way to manage disease problems. T

ACKNOWLEDGEMENTS

The contributors of this article would like to thank Teagasc's Martina Harrington, Catherine Egan and Nicky Byrne for their contribution to this research.

CONTRIBUTORS

Paul Crosson
Beef Enterprise Leader
Teagasc Animal & Grassland Research and Innovation Centre, Grange, Co. Meath.
paul.crosson@teagasc.ie

Mark McGee
Principal Research Officer
Teagasc Animal & Grassland Research and Innovation Centre, Grange, Co. Meath.

Pearse Kelly
Head of Drystock Knowledge Transfer
Teagasc Animal & Grassland Research and Innovation Centre, Grange, Co. Meath.

borzywoj/iStockphoto.com

Paving the whey towards a circular bioeconomy

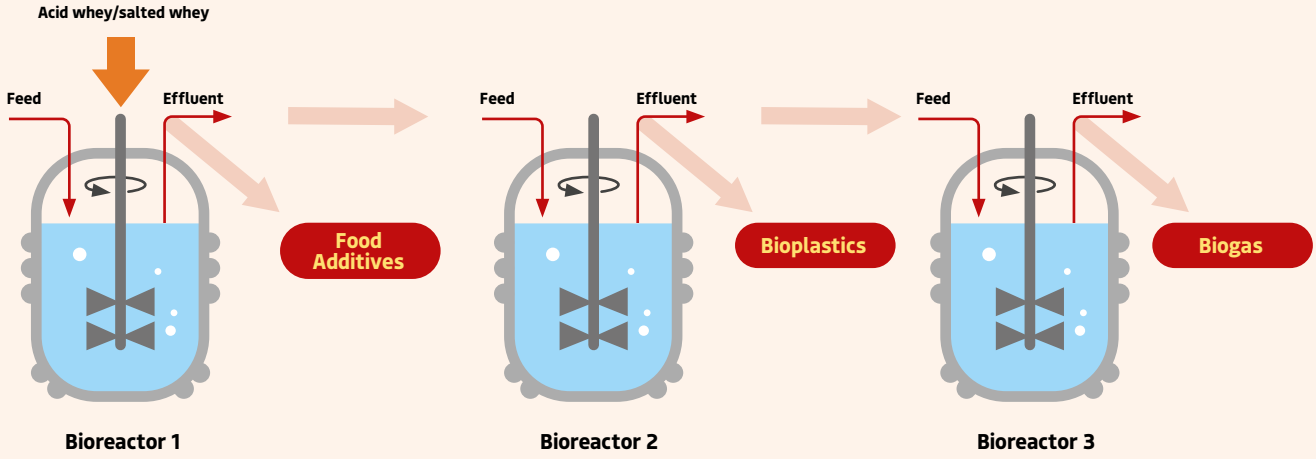
Teagasc researchers are collaborating with Munster Technological University (MTU), Ireland, and Lund University, Sweden, to transform dairy waste into value-added and environmentally sustainable products.

Whey, the main by-product of the dairy processing sector, is rich in lactose, proteins and micronutrients. Due to this nutrient-rich profile, whey and residues derived from whey have a very high biological oxygen demand (BOD) and chemical oxygen demand (COD).

Unfortunately, high BOD and COD levels are extremely hazardous to the environment if disposed of directly into waterways or on land. As such, dairy waste streams derived from whey need to be treated before they can be discharged – which can prove expensive.

Believing there is a better solution for this dairy waste problem, Teagasc researchers have partnered up with researchers from Ireland's Munster Technological University (MTU) and Sweden's

Figure 1. The EBSTAR biorefinery concept for acid whey and salted whey



Lund University, and established the EBSTAR project. Through this project, the researchers are investigating the use of microbial bioprocessing technology to transform dairy residues – particularly the underutilised acid whey and salted whey – into renewable and valuable products.

Understanding the different types of whey-based waste streams

The project team aims to generate high-value bio-based products such as food additives, bioplastics and biogas from low-cost whey waste residues, using a unique multi-bioreactor biorefinery process.

Depending on the technology utilised, various types of whey are generated from the separation of casein from milk to make cheese. The two most common types of whey are sweet whey and acid whey.

Sweet whey is generated from the production of most cheeses or casein products. The protein component of sweet whey is very valuable and is used to produce protein powders for infant nutrition, sport performance-enhancing formulas and food additives. After the protein is extracted from the sweet whey, however, the remaining lactose-rich component is underutilised.

Acid whey is generated from the production of Greek yoghurt, cottage cheese and acid casein, and it has a sour-like taste. It is complex to process in contrast to sweet whey because it has a low pH which affects protein stability. It is also difficult to remove water from acid whey.

There is a third significant dairy by-product that also needs mentioning – salted whey. Salted whey is generated during the production of semi-hard and hard cheeses such as Cheddar. It contains between 4% and 10% salt depending on cheese type, which affects its potential to be further processed into value-added products.

To improve the yield of bio-based products from these waste streams, the project team are carrying out their work with the aid of innovative bioprocessing techniques, the use of novel microbial groups and an adaptive laboratory evolution approach.

80 to 190 million tonnes

of salted whey and acid whey are generated annually.

Taking a circular bioeconomy approach

It has been recognised that the food sector needs to move away from an unsustainable linear model of production – or a 'take, make and waste' approach – to a more sustainable circular model. The goal is to reduce waste, the carbon footprint and the reliance on fossil fuels, all while helping to feed the rising world population.

Following a circular bioeconomy model – continuously producing value-added products and focusing on zero waste and pollution generation – is a major challenge for the dairy industry. But by harnessing the use of microbial fermentation technology to sustainably and efficiently biotransform low-cost materials such as whey-based waste streams into high-value bio-based products, the EBSTAR project is offering a potential solution for the dairy sector.

9L *of whey is generated per 1kg of cheese.*

A life cycle sustainability assessment will be conducted on this bioprocess system as part of the project, to assess its environmental impact and establish hotspots for cost and emission reductions. The hope is that this work will demonstrate the potential broad applicability of a multi-bioreactor waste valorisation system for dairy manufacturers and other industries, helping them to develop an economical and sustainable solution to making dairy waste residues commercially viable and renewable. T

ACKNOWLEDGEMENTS

The contributors wish to thank EBSTAR project partners Ed van Niel (Lund University) and Micheal Callanan (Munster Technological University).

CONTRIBUTORS

Brenda Barry
MSc Walsh Scholar
Biosciences Department
Teagasc Food Research Centre,
Moorepark, Co. Cork.

Eoin Byrne
Post-doctoral Researcher
Biosciences Department
Teagasc Food Research Centre,
Moorepark, Co. Cork.

Olivia McAuliffe
Principal Research Officer
Biosciences Department
Teagasc Food Research Centre,
Moorepark, Co. Cork.
olivia.mcauliffe@teagasc.ie

FUNDING

The EBSTAR project is funded by the Science Foundation Ireland Frontiers for the Future programme (ref. 19/FFP/6560). Brenda Barry is supported by the Teagasc Walsh Scholarship scheme (ref. 2019235).

Unlocking protein potential in Ireland

Teagasc researchers are exploring sustainable crop- and marine-based protein resources to create new opportunities for the agriculture and food sector in Ireland.

The Food Vision 2030 strategy aims to solidify Ireland as a world leader in sustainable food systems. At the heart of the strategy are four high-level missions:

1. A climate smart, environmentally sustainable agri-food sector.
2. Viable and resilient primary producers with enhanced wellbeing.
3. Food which is safe, nutritious and appealing: trusted and valued at home and abroad.
4. An innovative, competitive and resilient agri-food sector, driven by technology and talent.

To help embed the agri-food sector in a circular and regenerative Irish bio-economy, Teagasc has collaborated with University College Cork, National University of Ireland (NUI) Maynooth, NUI Galway, University of Limerick and Queen's University Belfast in a multi-disciplinary project known as U-Protein.

U-Protein is led by Teagasc's Mark Fenelon, Head of Food Research, and aims to unlock new sources of protein from crop and marine resources. The basis of the project is that Ireland's natural resources can be diversified to develop alternative protein sources, create an informed and diverse agri-ecosystem and accelerate Ireland's path to becoming a responsible global leader in the supply and knowledge of nutritious food solutions.

The overall objective of U-Protein is to identify and exploit existing and novel protein sources within the Irish agro-ecological system, in particular crop sources (grassland, cereals, legume, oilseed and niche crops) and the marine. Protein is the key driver of human health, growth and development, and by investigating compositional and functional properties of alternative proteins, U-Protein ultimately aims to deliver quality nutrition for consumers, while also supporting the competitiveness of the rural and coastal agri-economies.

Supporting Ireland in responsible food production

Research on U-Protein spans the entire production process, including the identification and characterisation of proteins from crop grasses, forage and the marine, the processing and sustainability of these proteins, clinical studies and finally incorporation into a consumer product. The protein crops identified include faba beans, peas, lupins, tubers and three different marine sources.

Protein has been extracted from identified sources that are suitable for growth in Ireland. In some cases, more than 75% protein has been recovered. In support of the sustainable circular bio-economy, the residual biomass from these protein sources will be assessed for bioactive components or valorised to novel or renewable products.

U-Protein has the potential to create a new food enterprise that can co-exist with dairy, meat and cereal sectors. The project team are vastly experienced in meat, cereal, marine and dairy protein science, and the learnings from these areas will be applied within the project.

With its trans-disciplinary approach, combining the expertise of leaders in a number of research institutes with significant industry support, this project will support Ireland's goal to become a global leader in responsible food production and address the critical unmet needs of the end users, most notably the agri-food industry and food consumers. T

CONTRIBUTORS

Muireann Egan
Communications Officer
Teagasc Food Research Centre,
Moorepark, Co. Cork.

Sinéad Fitzsimons
U-Protein Project Manager
Teagasc Food Research Centre,
Moorepark, Co. Cork.

Mark Fenelon
Head of Teagasc Food Research Programme
Teagasc Food Research Centre,
Moorepark, Co. Cork.

FUNDING

The U-Protein project has received funding from the Department of Agriculture, Food and the Marine, under the Food Institutional Research Measure (grant number 2019PROG702).

Events: my take-home message

Teagasc's researchers attend many events throughout the year, sharing the findings from their research with national and international audiences. Here, we capture the take-home messages – key pieces of information that our researchers want people to remember – from recent events.

Back in bloom

Event: **Bord Bia Bloom 2022**
Date: **2 to 6 June**

After a two-year break, Bord Bia Bloom – one of Ireland's largest showcases celebrating the best of Irish horticulture, food and drink – returned with a bang, with an incredible attendance of 113,500 visitors over five days.

Teagasc had an exhibit at the event, the theme of which was 'Healthy People – Healthy Planet'. As part of the exhibit, our researchers educated attendees on potential peat alternatives.

Eoghan Corbett, a Teagasc researcher working in peat research, says: "Visitors to the stand had a great awareness of how damaging peat harvesting is in terms of habitat destruction and, to a lesser extent, of how peat bogs represent an important carbon store.

"However, they were generally not aware of just how important peat is (and has been) in glasshouse crop, nursery stock, field vegetable and mushroom production, and how the professional horticultural sector depends on high quality growth media that provide reliable and predictable yield and quality of produce.

"We spent time discussing the potential that indigenous bio-resources (e.g. wood) and emerging technologies (pyrolysis) may have in peat-alternative substrate production. There was real interest in Ireland's move towards a more circular economy, whereby resources are better managed through their entire life cycle."

Teagasc's stand at the Bord Bia Bloom event

Over 1,000 people attended the 11th World Potato Congress

The changing world of the potato

Event: **11th World Potato Congress**
Date: **30 May to 2 June**

The 11th World Potato Congress took place this year, and was one of the first post-pandemic information and networking events for the global potato community. It was was organised by the Irish Potato Federation with support from Teagasc, the Department of Agriculture, Food and the Marine and Bord Bia.

Over the course of the four-day event, there were over 60 speakers, 120 poster presentations, 1,000 delegates and 57 commercial exhibitors.

Denis Griffin, a potato breeder at Teagasc and one of the co-ordinators of the event, says: "Although potato is the third most important food crop globally, it is still underutilised. Continual research, investment and promotion of this crop are necessary to unlock its tremendous potential, which is why events like the World Potato Congress are so important.

"A particular focus for the event was the sustainably credentials of the crop, with its excellent resource-use efficiency in terms of fertiliser, water, land area and growing period. It was evident to all participants that the crop has incredible adaptation, and allows for production – and, a result, research – from the equator to the Arctic Circle."

Save the date

Below Ground: Soil life in a changing climate

Date: 30 September to 6 November
Location: Johnstown Castle Museum

Do you know what goes on below our feet? A bustling community of plant roots, tiny animals, and microbes underpin our way of life – bringing us food, cleaning our water and regulating our climate. The life and wonder of soil is always with us, but rarely seen. So, we want to find out how vibrant soil communities are affected by climate change, and how this will affect us. Enjoy this exhibition from scientists and artists who bring the secrets of soil to life, and join us on our journey "below ground"!

This event is funded by Teagasc, Science Foundation Ireland and the British Ecological Society. It is part of the Festival of Farming and Food (Science Week).

Don't miss out on Teagasc's upcoming events! Visit our website to see what we have planned: www.teagasc.ie

Three's a crowd

Pictured we can see three hoverflies feeding on a native wild Teasel plant. These insects are the second most important pollinator after wild bees. Bees are capable of carrying more pollen per plant visit, but hoverflies are able to cover larger areas and make more plant visits. Hoverflies also take an active role in controlling aphid populations (which are carriers of plant viruses).

To help support pollinator populations, Teagasc's Oak Park Crops Research Centre has planted arable biodiversity field margins and hedges (herbaceous strips managed specifically to provide benefits for wildlife).

This photo was taken in August during harvest time on the front lawn of Oak Park House.

Photo and description by:
Fiona Hutton, Research Technologist, Teagasc

Teagasc project:
Integrated Pest Management in Tillage Crops