TResearch

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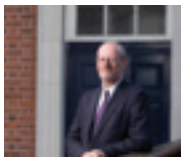

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More than "meats" the eye

A spotlight on Meat Technology Ireland, at the forefront of innovation in the meat processing sector

teagasc
Agriculture and Food Development Authority

Welcome

Producing sustainable and safe beef and lamb is the key to supporting Ireland's €3.1bn industry. This issue of *TResearch* includes a focus section on Meat Technology Ireland (MTI), a unique Technology Centre, co-funded by Enterprise Ireland and industry partners, committed to addressing the research needs of a sustainable beef and lamb processing sector.

We all know that digital tools are increasingly emerging as enabling technologies in the manufacturing sector. Indeed, advances in AI and the handling of large datasets has broadened companies' capabilities. Digitalisation has transformative potential for food processing, but adoption has generally been slow compared to other industrial sectors. In an article on p8, MTI scientists explain how digitalisation has the potential to transform red meat processing to handle contemporary challenges.

In our one-to-one interview on p14 with MTI's Director, John Colreavy, we learn how he brings a wide range of food industry development skills to the table. He tells us how MTI came about and how it is helping to support the development of the Irish beef and lamb sectors.

Then on p24 we meet some of the wider MTI team in the 'team spotlight' article. Susan O'Donoghue, Financial Controller, supports the financial management and reporting for all of the centre's grant-funded research projects. Ruth Hamill, Lead Principal Investigator, Digitalisation, works on novel applications for digital technologies in meat processing. Sarah Cahalane is an Industry Engagement specialist, who works as an Intellectual Property (IP) Officer for MTI, on behalf of Teagasc's technology transfer office, Engage@Teagasc. Finally, we meet Charlene Connolly, MTI Programme Manager.

Dale Crammond, Director of Meat Industry Ireland, rounds off the focus section in our external insight on p35. He explains how collaboration across the meat processing industries ensures that Ireland maintains a competitive edge in a fast-paced, high-value global market.

Catriona Boyle
Editor, *TResearch* magazine, Teagasc

Is é an rud is tábhachtaí chun tacú le tionscal 3.1bn na hÉireann ná mairteoil agus uaineoil shábháilte agus inbhuanaithe a tháirgeadh. Cuimsítear leis an eagrán seo de TResearch cuid fócais ar Theicneolaíocht Feola na hÉireann (MTI), Ionad Teicneolaíochta Uathúil, arna chómhaoiniú ag Fiontraíocht Éireann agus ag comhpháirtithe tionsclaíochta, atá tiomanta do aghaidh a thabhairt ar riachtanais taighde earnála próiseála mairteola agus uaineola inbhuanaithe.

Tá a fhios againn go léir go bhfuil uirlisí digiteacha ag teacht chun cinn níos mó mar theicneolaíochtaí cumasaithe in earnáil na déantúsaíochta. Go deimhin, leathnaíodh le dul chun cinn in IS agus láimhseáil tacar sonraí móra cumais cuideachtaí. Tá poitéinseal claochlaitheach maidir le próiseáil bia ag digitiú, ach níor glacadh go tapa leis den chuid is mó i gcomparáid le hearnálacha tionsclaíochta eile. Míníonn eolaithe ó MTI an chaoi a bhféadfadh an digitiú próiseáil feola deirge a chlaochlú chun déileáil le dúshláin chomhaimseartha in alt ar lch8.

Inár n-agallamh duine le duine ar lch14 le stiúrthóir MTI, John Colreavy, foghlaímid an chaoi a soláthraíonn sé raon leathan de scileanna forbartha tionscail bia. D'inis sé dúinn faoi bhunús MTI agus an chaoi a bhfuil sé ag cabhrú chun tacú le forbairt earnálacha mairteola agus uaineola na hÉireann.

Ansin ar lch24 buailimid le cuid den fhoireann MTI níos leithne san alt 'spotsolas foirne'. Tacaíonn Susan O'Donoghue, Rialtóir Airgeadais, le bainistíocht agus tuairisciú airgeadais do thionscadail taighde arna maonú ag deontas go léir an Ionaid. Oibríonn Ruth Harnill, Príomh-Imscrúdaitheoir, Digitiú, ar úsáidí nua do theicneolaíochtaí digiteacha i bpróiseáil feola. Is speisialtóir Rannpháirtíochta Tionscail í Sarah Cahalane, a oibríonn mar Oifigeach Maoine Intleachtúla don MTI, thar ceann oifig aistrithe teicneolaíochta Teagasc, Engage@Teagasc. Sa deireadh, buailimid le Charlene Connolly, Bainisteoir Cláir MTI.

Cuireann Dale Crammond, Stiúrthóir Thionscal Feola na hÉireann, deireadh leis an gcuid fócais inár léargas seachtrach ar lch35. Míníonn sé an chaoi a gcinntítear le comhoibriú ar fud na dtionscal próiseála feola go gcoimeádann Éire buntáiste iomaíoch i margadh domhanda tapa agus ardluachmhar.

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.

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Main image shows (L-R) Principal Research Officer Ruth Hamill, MTI Director John Colreavy and MTI Programme Manager Charlene Connolly at MTI technology centre, based at Teagasc Ashtown, Dublin.

Contents

Throughout TResearch, *we include icons alongside articles where there is a clear link to the urgent actions in our Climate Action Strategy. These actions are: Reduce Nitrogen Emissions, Reduce Methane Emissions, Increase Carbon Capture, Enhance Biodiversity, Increase Diversification, Enhance Adaptation, Circular Food System, and Supporting Policy. Teagasc's four research programmes, frequently referred to by their acronyms, are: Animal and Grassland Research & Innovation (AGRIP); Crops, Environment and Land-Use (CELUP); Food (FOOD); and Rural Economy and Development (REDP).*

Boosting circular bioeconomy innovation

As part of Bioeconomy Ireland Week, experienced entrepreneurs, leading venture capital companies and other financial institutions, gathered in Dublin recently to accelerate development of the circular bioeconomy in Ireland.

Maeve Henchion, a Teagasc researcher, says: "As the need to decarbonise our economy becomes more urgent and the business potential of the circular bioeconomy becomes clearer, we need to look at scaling sustainable innovation."

Maeve, who works on both the ShapingBio project and the BiOrbic SFI Research Centre, explains: "Funds need to flow from those that have them to those that can use them, and public funding alone won't do it. Through the EU-funded ShapingBio project, we have identified funding as one of the biggest hurdles to advancing the bioeconomy across the EU, signalling a need to improve the process."

Attendees at the event heard from representatives from successful spin-out and start-up companies, alongside key experts and investors. The event offered valuable insights into the ambition of scientists to go beyond academia to engage in addressing critical sustainability challenges. It was emphasised that scientists should and can remain dedicated to their core expertise, but that they need to surround themselves with business leaders and stakeholders to achieve success.

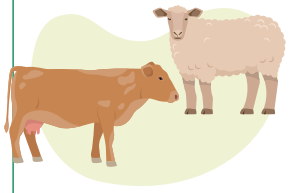
Noha Mahmoud, of Teagasc and theShapingBio project, summarises: "Without alignment between these funders and awardees, money won't flow and sustainable innovation will stall."

Teagasc's Maeve Henchion (left) with speakers at the event: Kevin O'Connor, UCD and BiOrbic, and Rosaline Beere, Business Consultant with FURTHR

John Ohle

Meat Technology Ireland

Meat Technology Ireland (MTI) is a globally unique, industry-facing collaboration committed to addressing the research needs of a sustainable beef and lamb processing sector



Genetics

Developing a breeding index to breed animals with reduced methane emissions at lower age at slaughter, while optimising the commercial potential of those animals

Meat quality

Establishing and translating the fundamental principles of meat quality while preserving the excellent food safety credentials of the sector

Digitalisation

Developing a roadmap towards a digitalised future for beef and lamb processing

Nutrition

Investigating the essential nutritional role provided by the inclusion of meat in the diet

Circular economy

Maximising the benefits that meat processing offer to the realisation of a truly circular economy though co-product valorisation

Academy Fellows appointed

Two Teagasc scientists have been appointed as Fellows of the International Academy of Food Science and Technology (IAFoST). Brijesh Tiwari, Principal Research Officer (left), and Declan Troy, Assistant Director of Research at Teagasc (right), were inducted as Fellows of the Academy at the annual conference of the International Union of Food Science and Technology (IUFoST).

The IAFoST is an elected group of food scientists, technologists and engineers who serve as Fellows of the Academy, distinguished by their scientific and professional contributions to the sector. They promote high standards of ethics and scientific endeavours among their peers and serve as a source of scientific personnel and information to support international activities related to food science and technology through IUFoST. New Fellows are inducted during each World Food Congress. Academy Fellows represent no organisation and serve as independent persons, forming a pool of scientific expertise from which IUFoST may draw non-aligned expert advice on scientific matters.

John Ohle

Makes EuroSense

Well done to Teagasc scientists who brought the EuroSense conference 2024 to Dublin, with over 750 delegates attending from across the world. The event was chaired by Teagasc researchers, Eimear Gallagher, Sinéad McCarthy and Emily Crofton with the theme 'A Sense of Global Culture'.

Emily explains: "New approaches across the globe to living, eating and the environment are shaping the future of sensory and consumer science. We put together an exciting programme of speakers across a broad range of topics, with applications for food and non-food products."

The speakers from 75 countries are presented the latest developments in sensory and consumer science across many contemporary topics addressing key global challenges such as health, sustainable food packaging, food waste, and new product innovations.

The opening keynote presentation was delivered by Joanne Hort from Massey University, New Zealand, who said:: "As food producers strive to provide enough food for the global population, and companies compete in a global market, it has never been more important for consumer sensory scientists to understand global variation in the drivers of food choice and preference, and the methodological approaches used to study them."

Teagasc Director Frank O'Mara (far left) with conference chairs (from second left) Eimear Gallagher, Emily Crofton and Sinéad McCarthy

News in brief

Abundance of Teagasc successes at IDF

Teagasc scientists really made an impact at the recent International Dairy Federation (IDF) event in Paris.

Maria Frizzarin (currently ICBF) won first prize in the early career scientist category for her work undertaken at VistaMilk/Teagasc on using individual cow mid-infrared spectral data to predict methane emissions and nitrogen use efficiency. Mark Timlin, a post-doctoral researcher at Teagasc, received the third-place prize in this category.

Teagasc, Bord Bia and ICBF won a 'Dairy Innovation Award for Sustainable Farming Practices' for AgNav – a sustainability platform providing Irish dairy farmers with accurate and verifiable data and supporting decision-making on farms to help reduce emissions and enhance water quality.

Teagasc also has a strong presence on IDF committees and a number of staff and scholars presented at the event.

Frontiers for the Future

Congratulations to Teagasc's scientists Song Miao and Norah O'Shea, who were among 40 recipients announced to have received funding under the Taighde Éireann – Research Ireland, Frontiers for the Future Programme, by Minister Patrick O'Donovan, TD.

Song's project will support the development of cutting-edge solutions in designing low salt food systems, with the potential to impact human health and well-being.

Norah's project, 4DSnacks, aims to develop a sensory-appealing and healthy snack using Irish ingredients produced by 4D food printing.

Launch of EU CAP Network report

The latest EU CAP Network report 'Women-led innovation in agriculture and rural areas' has launched to celebrate the International Day of Rural Women. This day of celebration was implemented by the United Nations General Assembly and aims to highlight the role and situation of women in rural areas. This report was produced in association with the Directorate-General for Agriculture and Rural Development, European Commission.

Pictured is a group of the Irish attendees at the workshop that led to the publishing of this report, including Teagasc economist Anne Kinsella.

European Commission

No chlorine, No problem

The implementation of minimum chlorate technologies across the dairy chain has facilitated the production of milk and dairy products with levels of chlorate residue superior to European Union and customer demands, whilst maintaining microbiological quality.

Chlorate is a degradation byproduct of chlorine that can disrupt proper functioning of the thyroid. In response to concerns about chlorate, dairy processors in the Republic of Ireland decided to prohibit the use of chlorine-based chemicals for cleaning on farms and in milk processing plants, effective as of January 1, 2021.

This decision stemmed from the need to ensure that milk complied with the legislative limits being placed on chlorate at European Union level, as a maximum residue limit (MRL) of 0.10 mg/kg for chlorate in milk came into effect in 2020.

However, little was known about the extent to which chlorine-free cleaning would reduce the risk of chlorate contamination, explains Lorna Twomey, a Walsh scholar at Teagasc Moorepark.

"Furthermore, there was a scarcity of information regarding chlorate levels in farm bulk milk and dairy products produced in Ireland. There was also a lack of understanding about the contribution of chlorinated water to chlorate in bulk milk. Of most concern was the fact that little was known about the microbiological impact of switching to chlorine-free cleaning."

Removing chlorine as a cleaning and disinfection agent meant removing a versatile and highly effective means of maintaining the cleanliness and hygiene of milk handling and processing equipment, potentially compromising the microbiological quality and safety of milk and dairy products.

To address these knowledge gaps, Teagasc, in conjunction with industry stakeholders, led a research project into chlorate residue in milk and dairy products and its relationship with cleaning protocols and milk quality, Lorna explains.

"This project aimed to develop a cross-dairy chain understanding of chlorate, as well as evaluate the efficacy of minimum chlorate technologies – chlorine-free cleaning and chlorine gas water treatment – from a microbiological perspective."

Setting the baseline

Research was conducted to determine the baseline levels of chlorate in farm bulk milk and dairy products. A total of 3,625 bulk milk samples sourced from six milk processors were analysed for chlorate residue. Of these, 1,741 were sourced in 2020 when chlorine-based cleaning was still employed on some farms, while 1,884 were taken in 2021, once chlorine-free cleaning had become mandatory.

In 2020, chlorate was present at detectable levels (≥0.0020 mg/kg) in 266 bulk milk samples (15% detection rate). With the imposition of chlorine-free cleaning this reduced to 149 samples (8%) in 2021. Moreover, the majority of samples (≥95%) analysed in both 2020 and 2021 were in compliance with the EU's MRL for chlorate in milk (<0.10 mg/kg).

To ascertain the typical levels of chlorate present in dairy products produced and consumed in Ireland, a total of 1,238 product samples were procured in supermarkets across 2021 and subsequently analysed for chlorate; product types sampled were whole milk, cream, cheddar cheese, butter and yoghurt. Although chlorate levels were detected in approximately half of all whole milk, cream and yoghurt samples analysed, these were significantly less than the EU MRL for the most part, and were virtually absent from butter and cheddar.

Chlorine-free cleaning measured total bacteria counts of

3,168

cfu/mL

vs

12,454

cfu/mL

in chlorine-based cleaning

Minimising contamination

Aside from its use in cleaning and disinfecting milking and milk processing equipment, chlorine is also used for water disinfection, Lorna explains.

"Therefore, risk of chlorate contamination is not limited to chlorine-based cleaning. Field trials conducted as part of this project confirmed, for the first time, that chlorinated water is a source of chlorate residue. The mixing of water and milk is the prerequisite for contamination; if this contamination is to be minimised, thorough drainage of milking equipment is essential."

At manufacturing level, many milk processors – especially those producing specialist products such as infant milk formula – have invested in chlorine gas water treatment as a means of eliminating the water supply as a source of chlorate. Chlorine gas technology is not prone to chlorate formation, in contrast to other types of chlorine, i.e. sodium hypochlorite and chlorine dioxide, Lorna continues.

"Chlorate levels detected in skim milk

nevodka/istockphoto.com

> When chlorine-free cleaning is combined with cognisant management of the water supply [...] effective minimisation of chlorate residue can be achieved.

powder were at 0.0183mg/kg when chlorine gas was used in production. By contrast, in previous research when chlorine was still commonly used, detected levels were at 0.057mg/kg – more than three times higher. Furthermore, we found that it is possible to produce high quality milk using chlorine-free cleaning. The total bacteria counts (TBC) and thermoduric counts (heat-resistant bacteria) of milk from farms using chlorine-free cleaning were lower than those achieved on farms using chlorine-based cleaning."

Chlorine-free cleaning measured 3,168 cfu/mL and thermoduric count 43 cfu/mL vs. chlorine-based TBC 12,454 cfu/mL; thermoduric count 92 cfu/mL.

Meeting the standard

Chlorine-free cleaning's ability to deliver milk with lower bacterial counts was attributed to the fact that on the study farms, chlorine-free cleaning was employed in accordance with a recommended protocol, i.e. having a hot water temperature of 75-80°C; employing the required number of acid washes each week; and using double the amount of liquid caustic detergent when washing with cold water (0.5% solution required when using hot water and a 1% solution being required when using cold water).

A subsequent research study focusing on the employment of chlorine-free cleaning protocols found that the majority of dairy farms in the Republic of Ireland were not fully adhering to recommended chlorine-free cleaning protocols, with 70% failing to use hot water of sufficient temperature (75-80°C at the start of the hot wash cycle), 50% failing to conduct the required number of acid washes, and 60% of farms failing to use extra caustic detergent when using cold water.

At milk processor level, the use of chlorine-free cleaning was found to deliver dairy products with 'in-spec' levels of bacteria, including mesophilic and thermophilic thermoduric bacteria. Moreover, the use of chlorine-free cleaning in conjunction with chlorine-gas water treatment does not compromise milk product microbiological quality.

"The aforementioned research demonstrates that eliminating chlorine as a cleaning and disinfection agent leads to a reduction in the incidence of chlorate in bulk tank milk and finished dairy products, all whilst preserving microbiological quality – provided chlorine-free cleaning is employed correctly," concludes Lorna.

"Moreover, when chlorine-free cleaning is combined with cognisant management of the water supply – thorough drainage of chlorinated water from milking equipment and the use of chlorine gas treatment at milk processing sites – effective minimisation of chlorate residue can be achieved." T

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Reduce Methane Emissions

Meat-ing the demand

Uptake of digital tools in the food sector is not yet widespread, but has the potential to transform red meat processing to handle contemporary challenges.

Digital tools are increasingly emerging as enabling technologies in the manufacturing sector. The concept of a digitalised manufacturing industry, Industry 4.0 (I4.0), is built on generating and connecting shop-floor data with enterprise. By digitalising and automating aspects of real-time decision-making, companies can streamline their production process, increasing efficiency, productivity and sustainability metrics.

Advances in AI and the handling of large datasets has broadened companies' capabilities. Digitalisation has transformative potential for food processing, but adoption has generally been slow compared to other industrial sectors. Yet, digital capability is vital in the face of unprecedented population growth, food security issues and the climate crisis.

Promoting uptake

Red meat processing is a significant sector of the Irish agri-food industry, supporting regenerative agriculture and the conversion of marginal land not suitable for crop production for human consumption. However, it is a low-margin enterprise challenged by a lack of skilled labour and the sustainability of its raw materials, explains Ruth Hamill, Principal Research Officer at Teagasc Ashtown.

"Red meat processing throughput is expected to increase by 14% by 2030. Red meat provides a high-quality source of nutrition; increasing demand is a hallmark of the expanding middle class in emerging markets worldwide."

This increased demand highlights the importance of digitalisation. Key technologies in I4.0 offering transformative potential to the meat sector include AI and data analytics, sensors and computer vision, digital twin and automation.

Despite interest among food companies, data analytics uptake has been slow; hampered by a high proportion of their data not being integrated and – in many cases – not digital. However, data analytics and AI hold real potential for meat processing, Ruth adds.

"Many vision-systems have been developed – some commercial, some at lab-scale – with the ability to predict information at individual carcass and meat level – such as carcass yield, hygiene and attributes like marbling."

Phase 1 research by Meat Technology Ireland (MTI) on digitalisation confirmed the capability of vision-systems. Phase 2 will deliver a digital-maturity-readiness assessment across the red meat sector in Ireland, and a state-of-the-art review of international automation adoption in meat processing.

In fact, Ireland has shown a global leadership role in digital adoption in meat processing, Ruth adds.

"In 2004, based on Teagasc-led research, Ireland became the first country to introduce video-image analysis to replace human graders in abattoirs. Recent MTI research holds promise for a new generation of technologies to support knowledge-based processing operations."

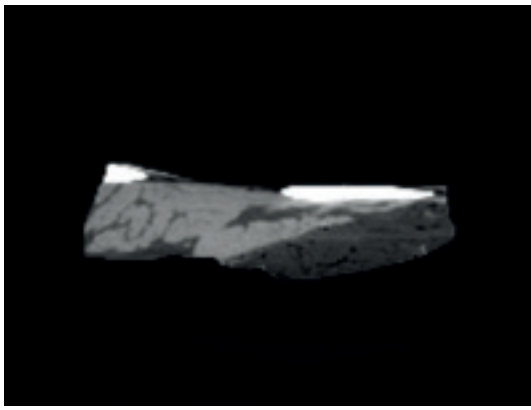
> **"Recent MTI research holds promise for a new generation of technologies to support knowledge-based processing operations."**

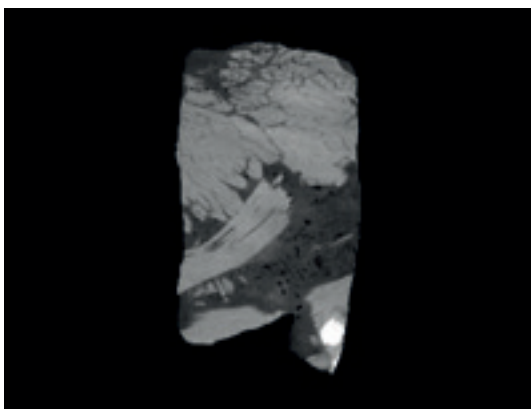
Getting a sense for it

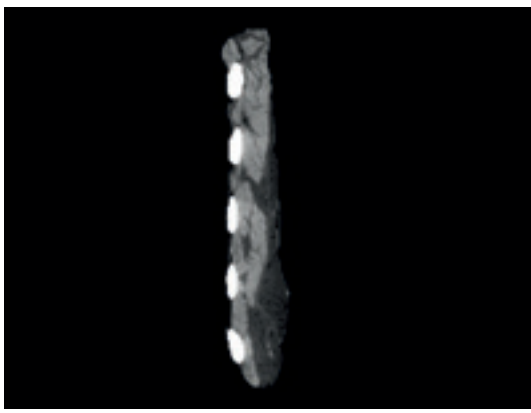
Data is not limited to visual images. Increasing sensorisation in red meat processing plants can provide in-depth information on variability in raw materials and process conditions. In turn, this provides deeper insights into ultimate performance – in terms of quality, hygiene or traceability.

At lab-scale, many sensors have been assessed for their ability to rapidly and non-invasively predict information such as sensory quality, stability, provenance, authenticity and safety. These include ultraviolet, visible near-infrared, Raman spectroscopy and Fourier-Transform, nuclear magnetic resonance, TeraHertz, and Electronic Nose spectroscopy – while X-ray computed tomography can provide accurate ground-truth information on carcass and meat composition and structure.

Sensorisation can potentially support companies in producing consistent high quality product and support appropriate







inventory management, says Ruth.

"While uptake has been relatively limited, we may soon bridge the gap – increasing the availability of technologies compatible with the pace of plant operations. Within the MTI digitalisation research theme, this is being assessed in conjunction with contemporary AI approaches, to inform the industry on how digitalisation can enhance operations at industrial scale."

Simulation and real-time data visualisation is made possible with data analytics – a powerful approach exemplified by digital twin. Digital twin allows process changes to be modelled and assessed dynamically without the need for costly downtime in commercial operations, Ruth explains.

"In the meat sector, The Australian Meat Processor Corporation developed a digital twin in tandem with virtual reality to support staff training during COVID-19 through digitalised representation of the actual factory. They plan to incorporate sensor data to monitor product movement through the factory in addition to monitoring equipment status to move toward spatially anchored predictive equipment servicing."

Improving worker welfare

Automation uptake in food is also low, compared to other sectors such as medical device and pharmaceutical, especially for applications in the boning hall.

"We see higher uptake in poultry and pig-meat processing, while automation adoption in beef has been limited to operator-assisted power-tools to minimise lifting and cutting hazards. The size and variability in raw materials is a contributing factor to the challenge," Ruth explains.

Developments in AI, computer vision and novel sensing modalities are providing fresh momentum; MTI is scoping out possibilities for automation to address processing yield efficiency (vision-enabled robotic-incision) and support for operatives in meat plants – including labour-saving and ergonomic supports, such as collaborative robotics in product handling.

Staff recruitment and retention is another challenge that automation may help tackle. Other sectors show that adopting automation not only improves output and efficiency, but also increases the proportion of high-skilled technical opportunities, Ruth says.

"Many I4.0 automation technologies are oriented to enhancing worker welfare, and target occupational health and ergonomics – for example haptics, wearables and collaborative robotics to work alongside operatives and butchers, supporting heavier and repetitive tasks."

Adopting I4.0 technologies will provide important benefits and support more effective knowledge transfer to staff. For example, AI-enabled computer vision can be applied to monitor and support correct use of personal protective equipment in the work setting, and AI approaches can ensure integrated training in an array of languages.

In Ireland's red meat sector, MTI digitalisation research is supporting efforts to reduce carbon emissions. Measuring emissions and identifying the causes of variability are prerequisites to the sector's ability to put in place systems to manage and reduce emissions, Ruth explains. "MTI research is focused on collecting and connecting one of the world's largest digital datasets from methane on the farm to quality in factory. This presents an unrivalled opportunity for Irish food production systems to be positioned sustainably as we move towards 2050." T

X-ray computed tomography-based reconstruction provides ground truth information on tissue structure in beef rib

Teagasc

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Enhance Adaptation

Weathering the storm

Farming can be a uniquely stressful occupation, with farmers often feeling subjected to changes outside their control. Joint research from Teagasc and Dublin City University seeks to understand these sources of stress.

The occupation of farming is filled with uncertainty, as farmers contend with changes in their work, the weather, and European and Irish agricultural policies. FarMHealth is a collaborative project between Teagasc and Dublin City University that aims to empower farmers to maintain their wellbeing and resilience. Part of this lies in better identifying and determining uncertainty in farming, and its ramifications, says Joseph Firnhaber, Research Officer at Teagasc Ashtown.

"A useful concept to understand how this uncertainty may impact farmers' health is 'liminality' – the experience of being caught on the threshold between one thing and the next, or caught in the midst of rapid changes," he explains.

"While liminality can be stressful, it can also present people the opportunities for personal, mental or career growth. Therefore, we aimed to identify sources of occupational stress or wellbeing for Irish farmers, particularly regarding change in their lives and communities."

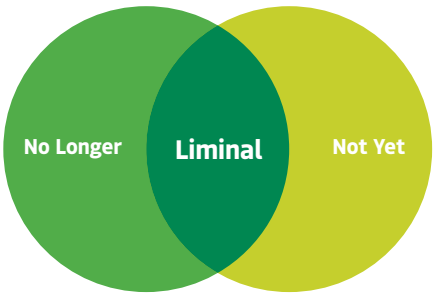
The project collected data online through individual interviews with 17 farmers, and one interview and three focus groups with 11 farming stakeholders. Researchers used narrative analysis to identify how participants described various changes relevant to farming, Joseph adds: "As a result, we identified four central narratives, three of which were negative – Rapid Change; Governance Standards; Rural Isolation – and one positive: Wellbeing from Farming."

In the first narrative, participants described how rapid changes to farming – whether due to policy, weather, or another source – rarely present opportunities to farmers. Instead, these changes create stress by increasing uncertainty and threatening farmers' financial security. As one participant expressed it:

> *"You have so little control over so much of what you do [it's] actually just [...] constant stress."*

Participants specifically identified how smaller family farms, and the family farming lifestyle, are being "eradicated" by these changes.

> *"Money is the overriding stress factor with farmers. If their mental health is bad it's because of money [...] The smaller family farms used to be really big, the backbone of the farming community in Ireland [but now] it's a long slow death for most of us."*



Cast as 'bad guys'

In Governance Standards, the second narrative, participants described how farmers feel stressed, caught between competing policy and governance standards in farming. They highlighted how recent environmental policy changes may be stressful to farmers mainly because they conflict with recent guidance to intensify their businesses:

> *"While farmers were told for years to 'just put cows on the ground' [...] Now we're being told, 'hang on, you've put too many*

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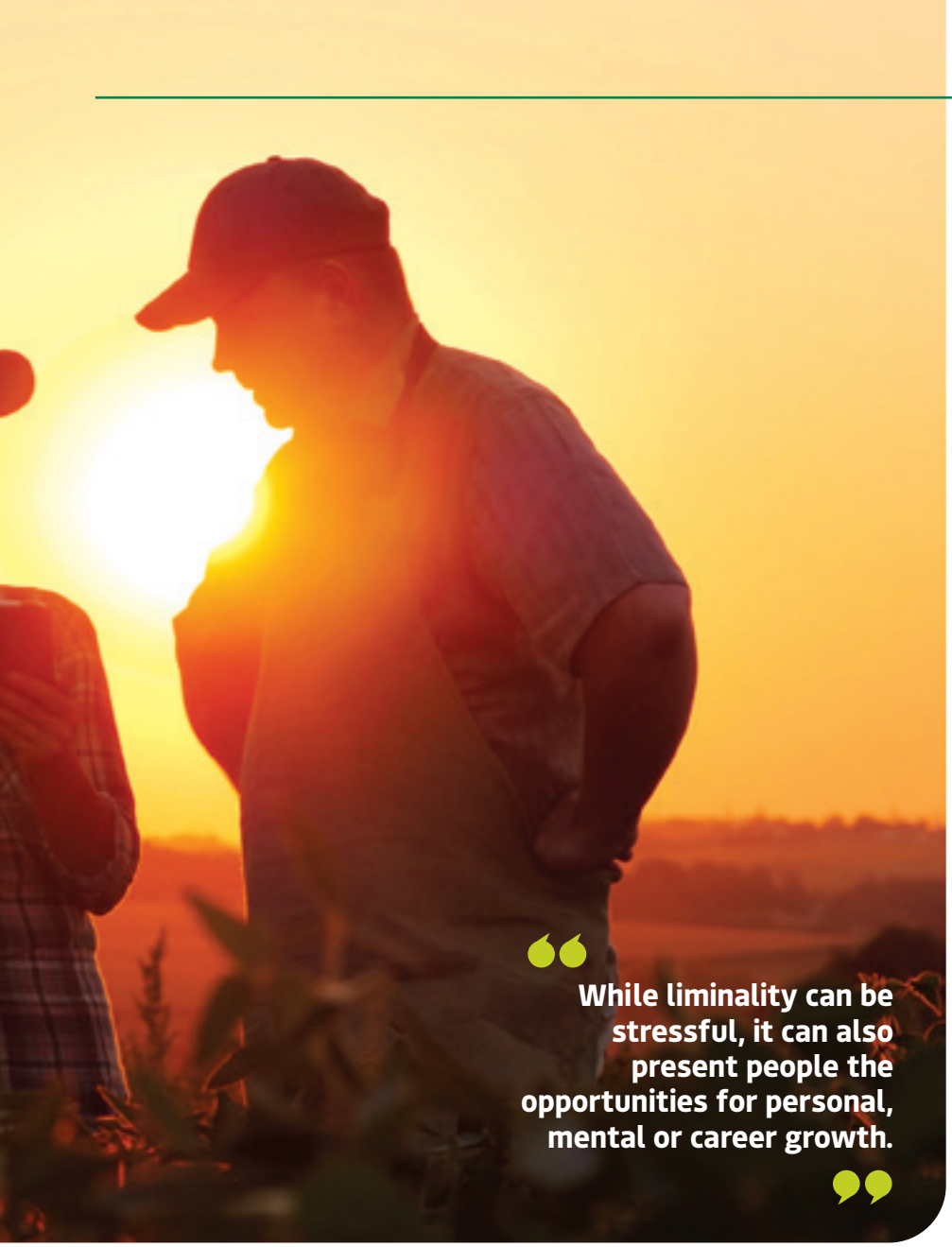

> **While liminality can be stressful, it can also present people the opportunities for personal, mental or career growth.**

cows out there' [...] Can't but put your head in a [...] bad place."

Importantly, participants didn't oppose environmental policies on principle. Instead, negative feelings stemmed from a sense that recent policies cast farmers as the 'bad guys' for following previous guidelines, rather than recognising their important role:

"We're doing our good and our bad, but in the main world we're also providing a very important thing, which is food for eating, which [...] we need more than lots of other things in the world."

The third central narrative was Rural Isolation. Here, participants described how stressful changes have played out in farming communities as well. These communities are growing more isolated and less cooperative, and the whole identity of rural life and the work of farming is being challenged. As the culture becomes increasingly focused on remaining economically competitive, farmers are "being isolated even more":

"Look at rural Ireland long ago when the door was open [...] there was no rural isolation back then, you know [...] If there was a job required on the farm they were all around helping you know. That's [...] not there now."

New and old pressures

In the sole positive narrative to come out of the study, Wellbeing from Farming, participants highlighted the traditional work of farming – such as being active, working with animals and family, and working in nature – as the main source of wellbeing in agriculture. This was the only point of stability that participants described in an occupation otherwise felt to be rapidly changing in a negative way.

"That's [...] milking for me [...] I absolutely love milking because it's time for me, and it's just me and cows. Now, the girls do milk a good bit with me but like it even gives us the chance to have a conversation where sometimes we'd be passing each other [...] I literally do my best thinking inside the parlour."

Effectively, these farmers and farming stakeholders described farmers as caught in a stressful and liminal state: struggling to stay afloat amidst rapid economic and cultural change, concludes Joseph.

"They painted a very pessimistic picture of the current state of Irish farming, with many of the changes at the expense of farmers and their communities' mental health, and very few opportunities."

The researchers' analyses illustrate how these cultural, political and economic changes can impact farmers' identities and wellbeing as they grapple with new and old occupational pressures.

"Our study suggests that economic policy and agricultural governance prioritise farmers' financial security and mental health, and acknowledge farmers' importance to the country, and their valuable contributions to rural life." T

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Enhance Adaptation

Switching off the (b)lights

Pesticide resistance is an increasing challenge in crop production. The Teagasc-led project IPMorama seeks to drive crop resistance to mitigate issues around heavy pesticide use.

The European Commission's Farm to Fork strategy aims to create a fair, healthy and environmentally-friendly food system. It sets ambitious goals to reduce, by 2030, the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50%.

A key element in achieving this is widespread adoption of integrated pest management (IPM) approaches – combining cultural, physical, biological and chemical tools in a way that maximises disease control whilst minimising risks to human health and the environment.

Current disease and pest management approaches in tillage crops incorporate many of the characteristics of IPM. However, one important element frequently underexploited – or missing completely – is using varieties that have been bred for resistance to pathogens and pests. To address this, Teagasc is co-ordinating a new Horizon Europe project called IPMorama, which started in September 2024.

Dan Milbourne, the Teagasc Senior Research Officer coordinating the project, explains: "With 17 partners across 10 European countries, the goals of IPMorama are to develop an increased capacity to breed disease- and pest-resistant crops, while also developing IPM strategies that exploit these resistance characteristics to reduce the need for chemical pesticides. We call this variety-centric IPM."

IPMorama will focus on wheat, potatoes and grain legumes (soy, pea and lupins), looking at important diseases and pests of these species, such as late blight and rust disease. The project will develop a whole practice ecosystem for variety-centric IPM, based on four main components.

Developing the tools

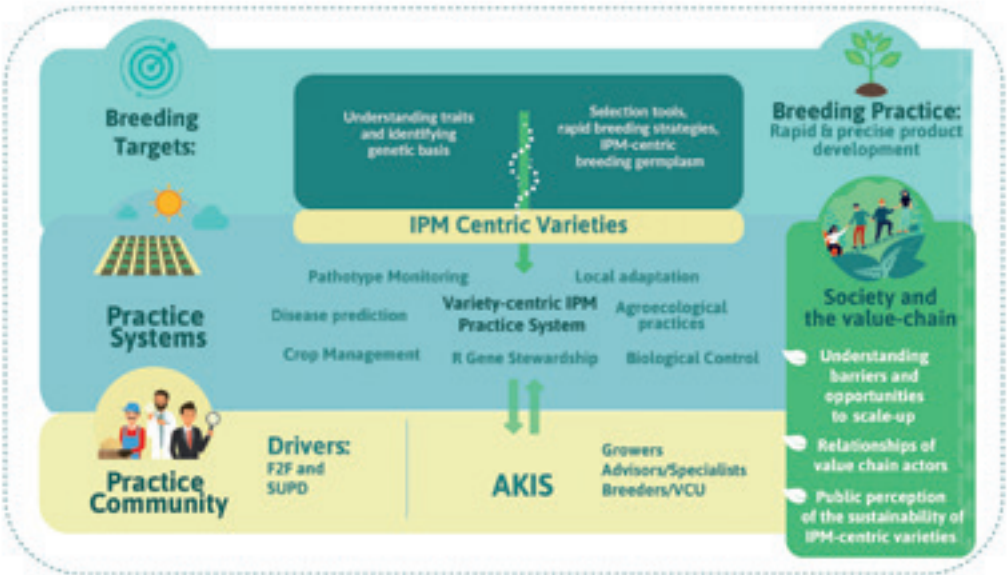
The first component involves developing tools to help breeders more effectively select for resistant plants, and will use these to develop resistant breeding lines that can be exploited by breeders during and after the project.

"As part of this, we'll characterise the genes upon which the resistance is based, which is important because pests and pathogens can evolve to overcome these genes," explains Dan.

The second component is understanding the distribution of virulent pathogen strains capable of overcoming plant resistances: monitoring the emergence and prevalence of new strains and whether they can overcome available resistant varieties.

"This allows us to develop optimal IPM approaches for crops in the third component of IPMorama, in which variety-centric IPM solutions will be upscaled from experimental plot level to whole farm level," Dan continues.

Blight trials at Oak Park illustrate the devastating potential of late blight on potatoes



The fourth component is to upskill the entire crop value chain in the use of IPM tools and strategies developed in the project, and to understand the practical and societal barriers that might prevent their uptake.

The urgent need for IPM strategies that incorporate resistant varieties is illustrated by disease control problems currently being experienced in one of the IPMorama target crops, explains Principal Research Officer Steven Kildea.

"Unfortunately, the potato varieties we favour for food purposes are often extremely susceptible to late blight, caused by *Phytophthora infestans*. To prevent the disease from taking hold, farmers must

Teagasc

> A new generation of potato varieties, with resistance based on both single and multiple blight resistance genes, is currently emerging on to the market.

regularly apply fungicides as the crops develop. Without doing this the Irish and wider European potato crop would fail."

P. infestans presents a moving target through the rapid evolution of new strains. Since monitoring began, 46 such strains have been discovered. Whilst most have no real impact on blight control, some are resistant to important control fungicides.

Most recently, a *P. infestans* population called EU_43_A1 has been causing problems for blight control in Europe – developing resistance to not one but two of the key fungicides European potato growers rely upon to protect their crops.

Prior to the emergence of EU_43_A1, timely fungicide application of fungicides was a reliable method of keeping crops free of the disease, Steven explains.

"Unfortunately, the appearance of the first strains of EU_43_A1 in 2019 hinted at the limitations of this method. By 2022, it was clear that these strains had resistance to the important CAA fungicide family."

"This by itself would be a significant issue. Then, following the summer of 2023 it became clear across parts of western Europe that – in addition to CAA resistance – strains of EU_43_A1 had evolved resistance to the completely unrelated OSPBI fungicide class."

Facing the challenge

In September 2023, researchers detected CAA-resistant strains of EU_43_A1 in Oak Park, highlighting the potential threat of dual pesticide resistance in Ireland in the future. Because the threat to potato production of blight strains exhibiting resistance to multiple fungicides is so significant, the collective advice across Europe has unfortunately, been to apply more fungicide, Steven explains.

"Growers must mix different modes of action when treating crops, ensuring rates of fungicides are kept high, and must avoid delaying application – to counteract the possibility of late blight overcoming the crop, but also to prevent pesticide resistant strains from gaining a foothold".

IPMorama can offer real solutions to this problem, suggests Dan.

"A new generation of potato varieties, with resistance based on both single and multiple blight resistance genes, is currently emerging on to the market. IPMorama will make the development of these varieties easier in the future. Multiple genes confer more durable resistance. However, we shouldn't just release these varieties and rely on the resistance alone, as *P. infestans* may eventually overcome them."

IPMorama will develop IPM strategies with accompanying decision support systems, whereby varietal resistance and fungicides will support each other, making it far more difficult for pathogens to overcome either. This will likely be achievable while also reducing the overall number of sprays required to control the disease.

Dan concludes: "It's a win-win: securing the future of potato production in the face of this serious challenge, whilst at the same time becoming more sustainable." T

FUNDING

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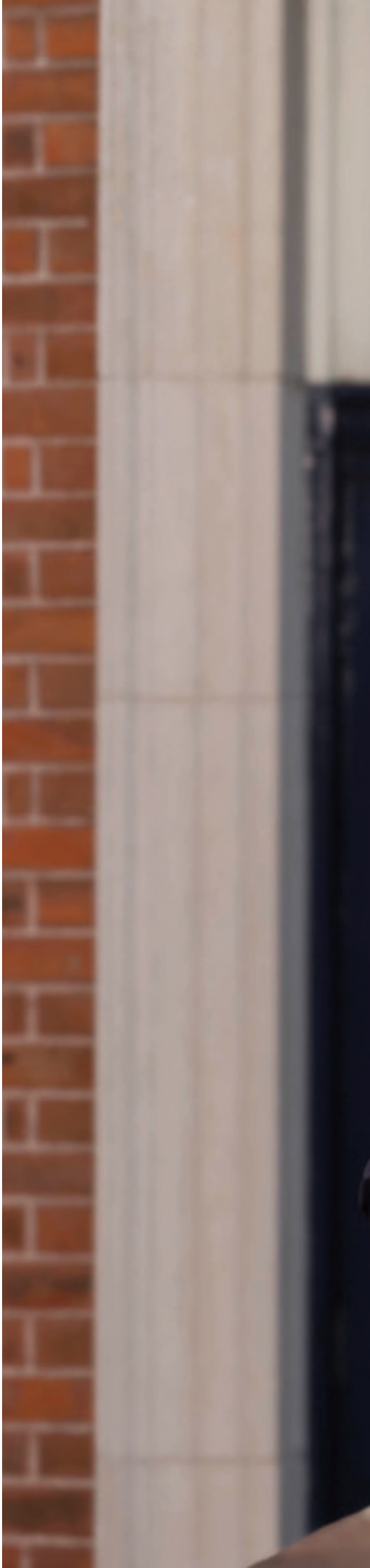
A longstanding career in applied science and innovation has made John Colreavy expertly qualified for his current role as Director for Meat Technology Ireland (MTI). He spoke to *TResearch* about the important relationship between science and industry, and MTI's unique offering.

Food for thought

Photography: John Ohle



Could you tell us about your career beginnings?

My first introduction to science and commercial enterprise was in the UK in the mid-'80s, at ICI. This gave me valuable insight into science's role in commercial enterprise and innovation, and in sectoral issues – be they commercial, regulatory or environmental. All of which we now see coming together in the food sector.

During my time in the UK, working across various leading industrial firms and completing my doctorate in tandem, I was able to keep to this throughline of science and innovation in a business setting. Crucially, this applied science angle had a strong focus on product and product performance.

In 1998, I returned to Ireland, joining a state agency working at a national competence centre for paints and coatings in Ireland. This setting had a wider reach for potential product applications, giving me a broader view of science's role in industry.

What was the genesis of MTI?

The first step towards what I do now was when the government decided to rationalise its laboratories. I was given a secondment to take the competence centre out to Dublin Institute of Technology (what is now TU Dublin) and to build a centre around all the elements you need for the applied science market. This was built around three pillars: commercial consultancy work; R&D projects sponsored by industry; and our first steps into the academic space, training PhDs and publishing research work.

When my secondment ended in 2012, the agency asked me back to fulfil a role of my choosing; this ended up being as a development advisor for food companies, particularly meat processors. A key topic was that meat companies wanted a scientific centre of competence; they weren't sure what it would look like, but the dairy sector had already done it, so there was precedent.

I was tasked with working collectively with meat companies, and the wider sector, to develop, design and build the centre. This is where MTI came from. I was calling upon the agency's models which had worked well in dairy and other sectors such as pharmaceuticals and electronics, but I was also bringing in all my industry experience of the "why" of applied science to suggest that the sector needed a competence centre of this type.

An external provider came in to help the sector configure a joined-up research programme. This level of research collaboration between companies was unusual, so they needed to trust the model as to how intellectual property would be handled, and what control they'd have over the programme and dealing with their own competitive tensions. Having a well-prepared model from Enterprise Ireland that had previous success in other sectors helped instil confidence.

As MTI's director, John Colreavy enjoys bringing together science and industry, tackling some of the biggest challenges the food sector faces today

What is MTI's remit?

Enterprise Ireland was very keen to foster co-opetition, or cooperative competition. This means that not only are Irish beef processors competing domestically, but Irish beef is competing in global markets, and you thus want to have high confidence and shared competence across all processors who are supplying those markets. Considering that, what should be addressed by a centre's research programme?

Industry members chose the five main topics as:

- Genetics and breeding, and thus meat quality.
- Food safety and shelf life.
- Digitalisation and a digital future.
- Meat and health and nutrition.
- The circular economy – minimising waste, maximising value.

What does the day-to-day look like?

We schedule our projects a quarter in advance, according to milestones and deliverables, or to certain issues we're trying to address. Every month, industry members and lead scientists come together to discuss projects and present results.

This puts the relevant companies in the room alongside the centre's management and lead research scientists. You're discussing results and seeing whether there's commercial opportunity in them. Each project gets presented twice a year so that we can track its progress; is it still relevant? Is it still working the way we want? What do we need to do differently?

We also have a separate, dedicated IP committee of specialists from industry and research-performing organisations, for looking at patents and licences. If a company spots an opportunity in the research, they're able to jump on it early.

What makes MTI unique?

Something that distinguishes us from similar innovation/enterprise projects is that we're structured like a company. We have a steering committee, who are essentially the board; we have stakeholders from the funding agency, universities and industry. ▶

John sees MTI's model – melding approaches from research and commerce – as increasingly necessary to keep pace with innovation

We are ISO9001-certified, which is a quality management standard – so we're expected to continuously improve our business processes and we are beholden to our steering committee to deliver results and improvements.

It's challenging bringing together companies and research bodies that would normally be competing against each other, and to acknowledge and facilitate these different cultures and ways of working. Keeping that consortium together requires that you run and deliver a contract that's predictable, transparent and fair to all. This type of cross-collaboration is essential across global, diverse multinationals.

How has the approach to innovation changed over time?

In industry, organisations historically had large R&D budgets and well-populated labs. Now, they tend to say: rate of change is too fast, it's a resource-heavy area, how do you ensure you have qualified people?

Large global organisations began to understand that they needed to reach out to research institutions to collaborate. They wanted to tap into global research collaboration as well as bringing their own processes to bear in solving problems – especially as commerce and industry, and their challenges, become more global. There's been a natural move towards partnering with research organisations. The space that MTI fills – as an interface between commercial/academic – is becoming more normal.

> **By adding our work to what Teagasc is doing, we can answer questions no one else can answer.**

What key challenges is MTI tackling?

Our biggest challenge in the food sector is around sustainability and sustainable production. MTI's first phase was mainly about determining what the issues were that the consortium could work on together. This got us up and running with the fundamentals of meat science, in addition to new concepts around digitalisation and harnessing genetics.

Now, we're halfway through phase 2, which is fundamentally about sustainable beef production systems; validating these systems, and positioning Ireland as a global leader in this area. Part of this is the digitalisation theme; how can digital tools improve the meat processing sector, what does the future 'digital factory' look like?

There's lots of pressure on the industry – sustainability concerns, the methane questions. Our core programme is focused on fundamental questions affecting everyone across the sector. Because it's so targeted, and brings together leading researchers and the industry, it can tackle beef sustainability in a validated way.

Can you give us an overview of MTI's phases?

Phase 1 started with genetics, because Ireland has the world's largest animal breeding genetics database at farm level. MTI has now brought together that data with commercial enterprises and factories for a new understanding of sustainability.

Meat quality will always be a topic. This is something that the Irish sector is constantly improving on, decade on decade, post-BSE. MTI helps harness this improvement in terms of sharing best practice.

Food safety is likewise a recurring concern. If you move into other markets, outside Europe for example, there will be different food safety requirements, and different supply chain requirements. This ties into sustainability; new food systems may seem more sustainable, but do they meet safety and supply chain requirements?

The nutrition theme is about driving science-based – rather than anecdotal – public dialogue. Giving consumers the scientific facts they need to make choices around their diet. Finally, circular economy is about moving towards greater valorisation of co-products.

Phase 2 goes into looking at the carbon footprint of beef production, looking at all inputs along the chain, including animals' age to slaughter, their methane outputs – elements that tie directly back into the genetics question. A core strategic direction is finding the right balance in age-to-slaughter.

Up close and personal

What inspires you outside of work?

If I wasn't doing this, I would for sure be a musician; I love listening to and performing a range of music, everything from traditional Irish music to opera. I have always enjoyed painting, too, and I read deeply in classics and philosophy. I think it's important to invest in those other aspects of yourself to stay inspired and passionate and bring that to your science work.

The second area is a digital future. Bringing together farm data with our consortium gives us datasets on an unprecedented global scale. By adding our work to what Teagasc is doing, we can answer questions no one else can answer. Previously, the industry relied on modelled data – now we can model our own system with our own hard data.

What do you enjoy most about this work?

Getting a problem to solve, with tangible results. It frustrates me when scientists put up their research and get little real engagement. So, I enjoy facilitating the relationship between science and industry to collectively solve problems and identify innovations. Everyone has a responsibility in this knowledge transfer: science to communicate it and commerce to act on it. I think it's exciting that Ireland is uniquely positioned to tackle this area. T

ACKNOWLEDGEMENTS

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Enhance biodiversity
Enhance Adaptation

From the ground up: ten years of SIS

Ten years ago, the Irish Soils Information System (SIS) was launched. For this issue's Back in Time feature, Senior Research Officer Réamonn Fealy reviews its historical context, development and usage – and considers emerging demands for soil data and how these may be met by technology.

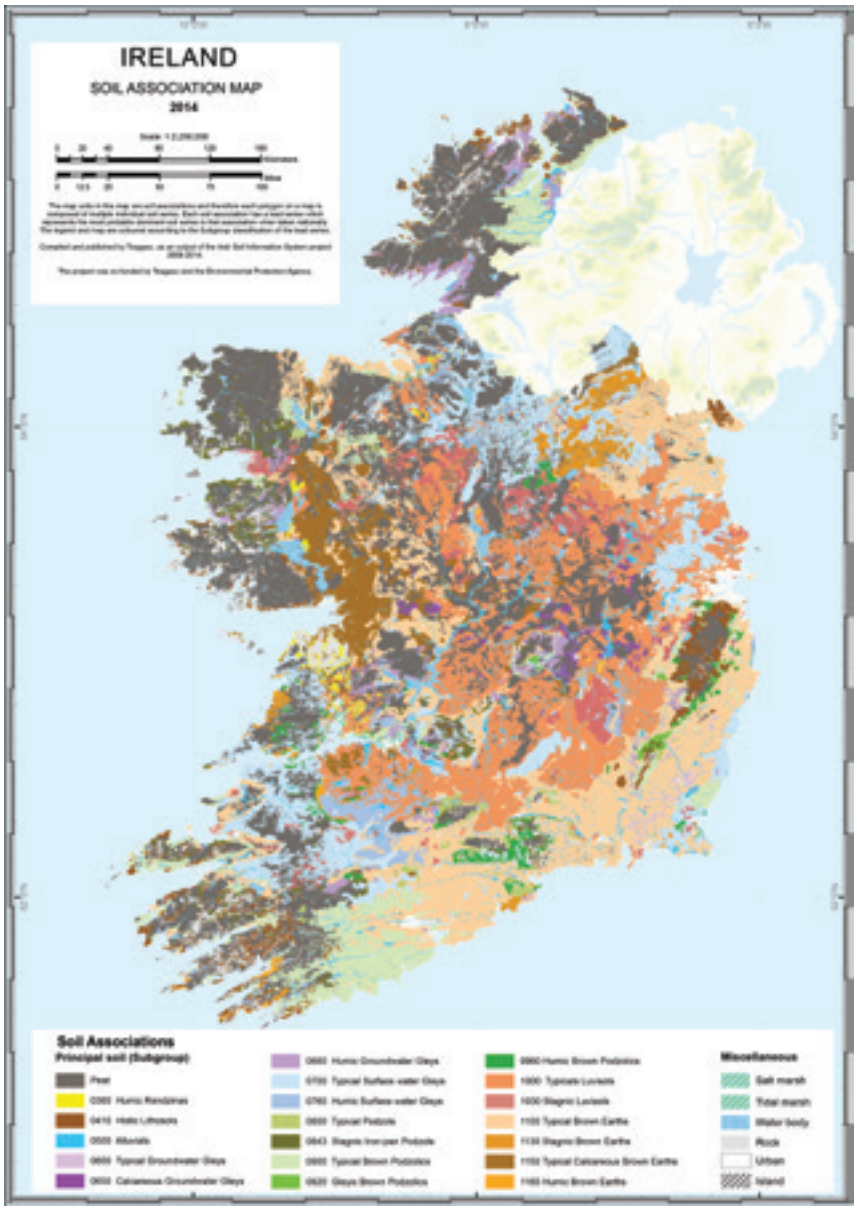
Due to the legacy of the Ice Ages in Ireland, soil mapping is particularly difficult here. While in some parts of the country the evidence is obvious, as in the classic drumlin landscapes, in other areas the signs are not so apparent. However, 1,000-metre-high sheets of ice traversing and ploughing up our landscape over millennia have had a profound impact on the development of soils that followed the retreat of that ice.

Due to this tumultuous geological history, the pattern of Irish soils is complex and mapping them is a challenging task, explains Réamonn Fealy, a Senior Research Officer at Teagasc Ashtown specialising in geo-spatial analysis.

"In contrast to many other areas of the world, there is considerable spatial variation evident, with subsoils and topography varying over short distances, giving rise to multiple soil types often occurring close together. ▶

A microplate of soil samples for analysis: methods like spectral analysis allow for rapid, accurate and non-destructive analysis

Andrew Downes, xposure



Irish Soil Information System

Of the 11 major soil types found in Ireland, nine of them were once mapped in a single field in Cork!"

Charting the unknown

In 1959, the National Soil Survey (NSS) was established within An Foras Talúntais (AFS). Its aim was to survey the soils in Ireland with a focus on agricultural potential, particularly grazing potential, and later to assess the distribution of marginal lands for the EEC Disadvantaged Areas Schemes.

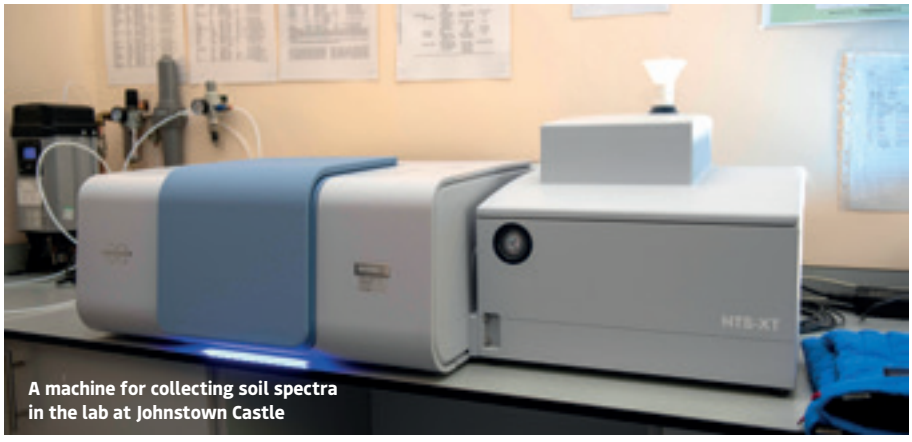
"When the NSS finished in the early 1980s, approximately 44% of the country had been published by county at 1:126,720 scale – or ½ inch:1 mile," Réamonn continues. "The second edition of the General Soils Map had been published at a scale of 1:575,000 and was based on a combination of both surveyed information and the application of derived soil landscape knowledge to areas not previously surveyed."

In 1998, in response to European legislation, and arising from the fact that over 56% of the country remained unmapped, Teagasc was tasked with producing the national Irish Forest Soils (IFS) Map. The map combined novel remote sensing and Geographical Information Systems (GIS) techniques, along with data from the previous soil survey, to create a predictive model of indicative soil types for previously unmapped areas. The national response to a subsequent initiative to produce a harmonised soils map for Europe led to the early conceptualisation of the Irish Soils Information System (SIS), explains Réamonn.

An EPA and Teagasc co-funded collaboration ultimately led to the creation of a comprehensive database of the soil types in Ireland.

"With the original design scoped out in 2007 by Teagasc research officer Karen Daly and myself, an EPA and Teagasc co-funded collaboration ultimately led to the creation of a comprehensive database of the soil types in Ireland. With this came the development of a new national map of soil associations at a scale of 1:250,000."

The SIS project built on the existing county surveys and IFS mapping, and in an extensive sampling effort provided additional field data collection for the counties not previously covered by the National Soil Survey. Cutting-edge models were developed for predictive mapping using landscape type and a wide range of environmental variables. The public website provides freely available access to the map and a database of soil types with detailed descriptions of the soil types occurring in Ireland.



A machine for collecting soil spectra in the lab at Johnstown Castle

Andrew Downes, xposure

Targeting (re)solutions

"Building on the work of our predecessors in AFS, the SIS 1:250,000 map was a remarkable achievement over a relatively short space of time and points towards exciting possibilities for the future," Réamonn continues. "Since its launch, it has attracted significant attention both nationally and internationally. Over 100,000 users have visited the SIS website with more than 80,000 of those users recorded from Ireland."

Despite significant advancements, there remains plenty of work to be done, he adds.

Soil Spectropy Technologist Felipe Bachion de Santana preps instruments for analysis

"The smallest area that can be represented on a map at 1:250,000 scale with any degree of confidence is approximately 250 hectares. To give you an idea, that's the equivalent size of roughly 38 Croke Parks or about eight farms of average size in Ireland. Emerging trends point to the need for new, more highly resolved data on Irish soils."

Foremost among these trends is the increasing focus on environmental sustainability, which requires farmers to implement measures to reduce greenhouse gas emissions, enhance carbon sequestration, improve water quality and restore biodiversity, explains Karl Richards, Head of Teagasc's Climate Centre.

"Targeted solutions are needed to ensure that the right measure is located in the right place at the right time to maximise impact. This requires higher spatial and temporal resolution of soil data. The Teagasc Climate Centre focuses on developing technical solutions to achieve the climate and biodiversity goals for agriculture and increasing the resolution of soil data will be key to this."

Increasingly, consumers and food purchasers are demanding access to verifiable sustainability data relating to the food they buy and eat. Farmers want to be able to measure the impact and improvements they make on their farms, continues Karl.

"Carbon farming, the soil health law, nature restoration law, all will require improved soil data at a higher spatial and temporal resolution. In the future, tools like Nutrient Management Planning (NMP) Online and the sustainability support framework AgNAV will likely need to include farm- and field-specific soil data to verifiably measure and report on areas such as carbon sequestration and soil biodiversity."

To help improve soil surveying and mapping, new research is looking at ways to make soil data collection easier, cheaper and faster, explains Karen Daly, Principal Research Officer at Teagasc Johnstown Castle.

"For the analysis of soil properties, Teagasc is developing and applying a well-known technique called infrared spectroscopy – used frequently in pharmaceutical sample analysis. When an IR light is shone on soil samples, an image or spectrograph is produced, which is like a fingerprint of that soil sample. The application of machine learning techniques enables us to turn those images into information and use data science to make sense of it. With a single scan, we can now measure up to 15 soil parameters without any chemicals for preparation."

Réamonn concludes: "In view of both emerging and future user requirements leading to soil data becoming increasingly prioritised, it is inevitable that the Irish soil data project will need to both continue and to be reinforced. It seems the historical words of R. S. Smith, Director in the United States Soil Survey, have never been truer!"

> *"...the soil survey will never be completed because I cannot conceive of a time when knowledge of soils will be complete. Our expectation is that our successors will build on what has been done, as we are building on the work of our predecessors."*
> R. S. Smith, Director Illinois Soil Survey, 1928 T

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Supporting Policy

Bubble trouble?

Joy Clarke, Teagasc Walsh Scholar, reports on the key results from her work on understanding how biocontrol and integrated pest management (IPM) approaches can support the mushroom sector in controlling disease outbreaks.

The mushroom industry is the largest horticulture sector in Ireland. Currently, there are 40 mushroom production units located across the country, producing a massive 68,000 tonnes of mushrooms annually. Growers are constantly monitoring their crops for the appearance of disease that could severely affect their yield and overall profits.

Several diseases may impact a mushroom crop; a research project at Teagasc Ashtown's Horticulture Development department focused on two important fungal mushroom diseases: dry bubble disease (caused by *Lecanicillium fungicola*) and cobweb disease (caused by *Cladobotryum* spp.).

Shroom for an alternative?

Traditionally, growers have relied on good hygiene and chemical fungicides to control disease. However, the number of approved fungicide products available has reduced considerably over the past 20 years and, with so few chemicals available, there is now a significant risk that fungicide resistance will emerge. The overall goal of this project was to investigate alternative disease treatment methods with a focus on biocontrol and integrated pest management (IPM) strategies, explains Joy Clarke, a Teagasc Walsh Scholar.

"Biocontrol involves the application of microorganisms to a crop that can prevent or reduce the growth of pathogens or pests. Often, these microorganisms have lived alongside the pathogens within the same environment and have naturally evolved ways to compete with them. When we increase the population of the biocontrol species, we hopefully anticipate that they will reduce the growth of the pathogens and thus reduce disease incidence."

In 2019, several bacterial strains were isolated from mushroom casing material and were tested for their abilities to reduce the growth of *Trichoderma*, a fungus that causes green mould disease on mushrooms. One bacterial strain that showed the best potential was selected to be the novel biocontrol strain included in this work. It was identified as a *Bacillus velezensis* species and was designated as *B. velezensis* Kos. The research team also chose to include a second biocontrol strain, *B. velezensis* QST 713, which is commercially available in the biocontrol product Serenade®.

Stress-testing

The project began with an investigation of the abilities of these biocontrol strains to reduce the growth of the pathogens which cause both dry bubble and cobweb disease *in vitro* or in the lab. This involved various inhibition assays and experiments, determining that growing the pathogens with the biocontrol bacteria caused significant growth reductions and physical damage to the pathogens, Joy explains.

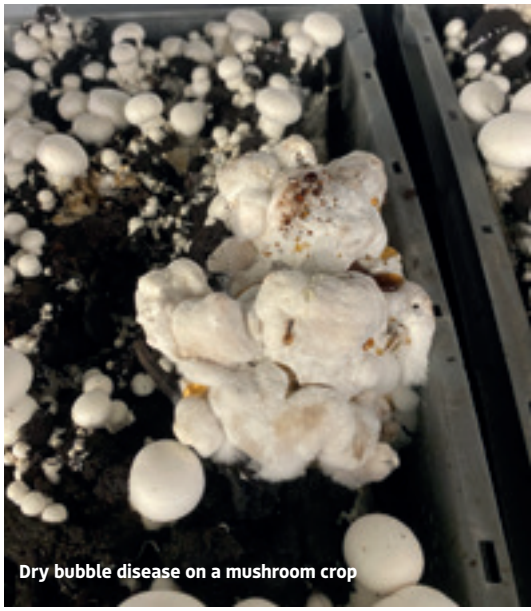
"We used proteomic techniques to learn more about this interaction. By investigating the different proteins which are expressed in response to treatment, you can essentially determine how the pathogen responds to the biocontrol bacteria. We found that stress-related proteins were increased when the fungal pathogens were exposed to the bacteria, and growth proteins were reduced."

Overall, the team saw extremely positive results from their lab work for both pathogens with both biocontrol strains. However, within a mushroom crop environment there will be several hundred additional microorganisms that may affect this interaction. The next task was to test the biocontrol strains in crop trials, to obtain more realistic results of how these treatments might work for the growers.

Trialling the treatments

The team carried out five large-scale disease trials in the industry-standard growing rooms at Ashtown's Mushroom Research Centre. The researchers infected crops with a pathogen – for either dry bubble or cobweb disease – and applied the biocontrol treatments to see if they could control disease symptoms.

"We also included traditional fungicide treatments, such as prochloraz and metrafenone, to compare the biocontrol



Dry bubble disease on a mushroom crop

We found that stress-related proteins were increased when the fungal pathogens were exposed to the bacteria, and growth proteins were reduced.

treatments to conventional treatment methods," Joys adds.

"Prochloraz performed very well during crop trials, inhibiting disease symptoms of both pathogens significantly and preventing significant yield reductions. However, soon after this work was completed, the approval for use of prochloraz on mushroom crops in the EU was revoked. At the same time, we identified pathogen isolates that were resistant to the remaining fungicide, metrafenone. These results emphasised the importance of finding alternative disease control strategies for the sector."

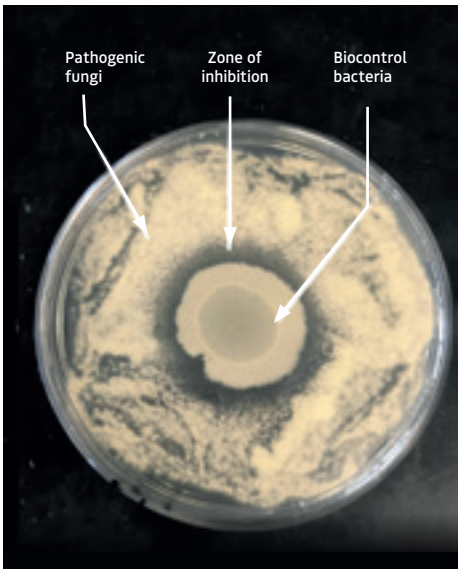
Joy continues: "Although we generated some positive results for the biocontrol treatments, we determined that the level of disease inhibition achieved was less significant than what we had seen in our laboratory work."

Chemical fungicides performed much better under high disease pressure, but the biocontrol treatments showed potential under low to moderate disease pressure. The researchers analysed samples of the biocontrol-treated mushroom casing over the course of a crop and found that adding these bacterial strains did not alter the natural casing microbiome population and that the biocontrol bacteria were not persisting after application.

"This could explain the differences between our lab and crop-based studies," adds Joy.

"Perhaps we need to look for biocontrol bacteria that are better able to compete with other microorganisms within the mushroom environment in order to improve efficacy in the field."

Pathogen inhibition with a biocontrol bacterium



Encouraging results

During this work, the researchers found that disease proliferation was significantly reduced on plots that were monitored carefully, and where any early patches of disease were treated with salt to kill off the pathogen. This is a key principle of IPM; these results are extremely important, as they prove that disease-monitoring and early treatment is a worthwhile IPM strategy for growers to apply on their farms, Joy explains.

"If we can encourage growers to combine this important IPM principle with the application of biocontrol treatments, it should be possible to reduce disease levels on mushroom crops, without having to rely heavily on fungicide products.

"Overall, the findings of this research have made significant contributions to a workable IPM strategy for the mushroom sector.

"We have shared these results with the industry through multiple presentations at global grower events – Dutch Mushroom Days 2023, 19th & 20th ISMS Congresses, 26th NAMC conference – as well as at scientific conferences," Joy concludes. T

FUNDING

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Detecting chromosomal abnormalities in cattle

DNA information collected at birth can now be used to detect chromosomal abnormalities in livestock, helping avoid the costs and challenges of rearing infertile cattle.

Chromosomal abnormalities in humans, such as having an extra or a missing chromosome, are known to cause various genetic disorders – many of which significantly impact health, development, and reproduction.

For example, Down syndrome – caused by an extra copy of chromosome 21 – leads to developmental delays, characteristic physical features and an increased risk of various health conditions. Similarly, Turner syndrome – which is caused by a missing X-chromosome in females – can cause short stature, heart defects and infertility, among other complications.

These types of chromosomal abnormalities are not limited to humans; they can also occur in livestock and generally result in infertility or the animal dying prematurely. However, animals with chromosomal abnormalities often appear normal externally, so their genetic condition typically goes unnoticed until they are either found dead or are eventually deemed infertile.

Figure 1: Karyotype testing of a heifer confirms she has an extra copy of chromosome 27

A novel strategy

Cliona Ryan, a post-doctoral researcher at Teagasc Moorepark, explains that the traditional method to detect chromosomal abnormalities is known as karyotyping.

"Karyotyping involves taking a blood sample from an animal, staining the chromosomes to make them visible, and then analysing the number and structure of the chromosomes under a microscope. Karyotyping is a labour-intensive process and costs approximately €60 per animal."

However, researchers at Teagasc Moorepark have pioneered a novel strategy. By using existing DNA profiles from the national cattle genotyping scheme, it's now possible to detect the number of chromosomes per animal at no additional cost to the farmer.

"Chromosomal duplications and deletions were detected by quantifying how much DNA was present for each chromosome in each genotyped animal," Cliona explains.

"This means researchers compared the actual amount of DNA for each chromosome to what is normally expected. If extra DNA was present for a specific chromosome then it indicated that the animal might have an extra copy of that chromosome. If less DNA was present for a specific chromosome, then the animal might be missing a copy of that chromosome."

Proactive detection

This newly developed, novel methodology was validated by collecting blood samples from animals suspected of having an additional or missing chromosome. The samples were analysed using karyotyping, with the number of chromosomes examined under a microscope, which allowed the researchers to confirm the suspected chromosomal abnormalities.

The cost-saving implications of this methodology are significant, continues Cliona.

"Given that one cytogenetic analysis – i.e. the examination of chromosomes to determine chromosome abnormalities – costs approximately €60, a whole-population screening of cattle in Ireland to identify affected individuals would cost €150 million annually – based on a figure of 2.5 million calves born per year. Specifically, for young bulls in Ireland that will potentially be used for artificial insemination, the karyotype testing costs approximately €600,000 annually."

However, affected individuals can be identified using their already available genotype information. This is due to the algorithms developed from this research being deployed by the Irish Cattle Breeding Federation to screen animals that are genotyped at birth, as part of the national genotyping scheme. This means that potential chromosomal abnormalities can be identified at no additional cost and very early in the animals' lives, allowing for proactive management decisions.

"Although the prevalence of chromosomal duplications or deletions in the Irish cattle population is relatively low, any identified cases [...] are likely to have notable financial repercussions."

Andrew Downes, xposure

Assessing the impact

Using a comprehensive database of almost 800,000 Irish cattle genotyped under 15 months of age, the incidence of chromosomal duplications or deletions in Ireland was 0.062%. The incidence of chromosomal abnormalities has not been previously reported in any cattle population globally.

None of the females identified with a missing X-chromosome (indicative of Turner syndrome) produced offspring, nor did any males with an extra X-chromosome (indicative of Klinefelter syndrome), as they were likely infertile. Among the 139 cattle detected with an extra autosome (i.e., non-sex chromosomes), which is a condition similar to Down syndrome in humans, 61% died prematurely on farm. The karyotype of a dairy heifer with an extra autosome can be seen in Figure 1.

"Although the prevalence of chromosomal duplications or deletions in the Irish cattle population is relatively low, any identified cases – whether on sex chromosomes or autosomes – are likely to have notable financial repercussions," explains Cliona.

The techniques developed by Teagasc researchers for identifying chromosomal duplications and deletions are not limited to cattle; similar chromosomal abnormalities have now also been identified in Irish sheep and horses.

"This methodology may have potentially far-reaching, positive implications for genotyping, breeding and culling across a range of livestock," Cliona concludes. "By detecting issues at birth, farmers can make informed decisions about breeding and culling." T

FUNDING

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Meat expectations

Meat Technology Ireland (MTI) is a national centre for research and innovation in meat processing, based at Teagasc Ashtown. Uniquely positioned, it brings together research organisations and industry partners to develop solutions to some of the biggest contemporary challenges facing the meat sector in Ireland, and the world.

Photography: John Ohle

Hosted by Teagasc, Meat Technology Ireland (MTI) is a unique, industry-led centre for research. To learn more, *TResearch* spoke to several of its core team members: Susan O'Donoghue, Financial Controller; Ruth Hamill, Lead Principal Investigator (PI) for Digitalisation; Sarah Cahalane, Intellectual Property (IP) Officer; and Charlene Connolly, Programme Manager.

Can you explain your role and objectives within MTI?

Susan O'Donoghue: As the Financial Controller, I provide support through financial management guidance and reporting for all of the centre's grant-funded research projects. My role began early on, assisting the centre's Director, John Colreavy, with preparing project proposals: calculating individual project budgets, and ensuring all pay rates and budget proposals adhere to Teagasc and Enterprise Ireland funding rules.

Ruth Hamill: During MTI phase 1, I was involved in the meat quality and meat characterisation research pillars. Currently I am the lead PI for phase 2's digitalisation research theme, which aims to identify, develop and assess novel applications for digital technologies in meat processing. This will provide the industry with a knowledge base to inform and support adoption of appropriate technologies to enhance efficiency, quality and sustainability.

Charlene Connolly: As MTI's Research and Innovation Programme Manager, my role is oriented around project management. This means ensuring that MTI collaborates closely with the industry and other Research-Performing Organisations (RPOs) to deliver successful, impactful research and innovation that will benefit the wider sector and provide a stepping stone for the next research phase. I also project manage all 19 MTI research projects.

Sarah Cahalane: I am an industry engagement specialist, serving as an IP Officer for MTI, on behalf of Teagasc's Technology Transfer office, Engage@Teagasc. Teagasc is the lead RPO for MTI, and Engage has played a key role in running and coordinating the collaboration since phase 1 began. MTI's research programme generates results that may lead to significant novel IP; I identify and oversee potential commercialisation opportunities of this.

How do you achieve these objectives? And how are findings presented?

Ruth: As MTI is an industry-led programme, the meat processing companies involved in the research are key stakeholders. We regularly update the industry leads and other relevant colleagues across these companies; our research allows them to explore and assess technologies relevant to their needs. Following due consideration of IP, we also present aspects of our research at conferences to inform the scientific community of developments.

The outcomes so far have potential to add value and improve efficiencies; several are currently being assessed under licence within companies and form a key part of the MTI phase 2 genetics programme to allow reduction in age at slaughter without compromising on yield.

Charlene: MTI conducts research projects in genetics, digitalisation, meat quality, packaging and shelf life, meat and health and circular economy. Research findings are discussed through an MTI research programme management group, which meets monthly, giving both RPOs and industry partners scope to discuss the project results and agree on plans to commercialise or publish the results.

Susan: I work closely with MTI's director; together we continuously monitor the project finances to ensure we stay within budget. All expenditure is reported every six months to Enterprise Ireland, our industry partners and the board, in the format of spend for the previous six months, spend to date and compared to budget.

Once a proposal has been approved by Enterprise Ireland and the funding awarded, my role continues with the ongoing financial management of projects, which includes continuous forecasting to ensure any inflationary exposure over the lifetime of the project is monitored and – if necessary – rectified with budget alterations. This ensures ▶

Hosted at Teagasc Ashtown, Meat Technology Ireland (MTI) brings together world-leading research with industry collaboration to drive significant innovation in the meat processing sector

that the budget remains within the budget envelope and ensures value for money is achieved.

Sarah: I regularly present to the IP committee on all IP-related queries and topics. These include: the terms of MTI's consortium agreement; IP management for potential collaborators; and background IP, which covers both novel results from MTI research and pre-existing IP that MTI researchers need to use to meet objectives. My advice helps the IP committee develop recommendations for MTI's central steering committee.

What key techniques and tools do you use in this work?

Sarah: In Ireland, we're fortunate enough to have a national protocol for IP, alongside guidance documents developed by Knowledge Transfer Ireland. This provides a consistent framework for all Irish tech transfer professionals to follow. I draw regularly on my own expertise and insights, having spent 14 years as a tech transfer professional within Teagasc, and regularly take part in workshops in tech and knowledge transfer.

Susan: Continuous monitoring of spend, maintaining accurate and up-to-date reports and constant communication with all relevant parties.

We also monitor wider economic factors – such as pay increases in the public sector – to ensure that our budgets can withstand external pressures and shifts.

Part of my role also involves the submission of six-monthly claims to Enterprise Ireland to ensure drawdown of the funds approved to finance the continuing research. This involves requesting the information from all research partners, analysis of the spend with the director and compiling and submitting the claim to the funder, as well as following up on any requests from the funder. The key part of my role is to analyse each return for accuracy and ensure that they comply with Enterprise Ireland's financial policy.

Ruth: We have been funded by Teagasc and Enterprise Ireland to procure a range of imaging equipment, including a CT scanner for 3D meat characterisation; novel sensors that have applications in meat and carcass quality characterisation; and computer vision technology.

Furthermore, the most advanced ribeye grading technology, based on 3D vision and AI, is being applied in MTI research. We have also developed a novel spectral imaging system that is under patent application.

> **"Having the industry so involved with MTI and every step of our decision-making process ensures that our results are focused, relevant and impactful for our sector and the challenges it faces."**

Charlene: Having the industry so involved with MTI and every step of our decision-making process ensures that our results are focused, relevant and impactful for our sector and the challenges it faces.

Can you explain your work's relevance in the context of Irish agri-food?

Ruth: We are testing and developing new technologies that will benefit the wider industry, especially in areas like worker welfare and meat and carcass quality. We are also training the next generation of researchers in digitalisation.

Advances in automation and digital technologies have the capacity to improve process efficiency and protect worker welfare

Charlene: The meat sector in Ireland remains one of the most important indigenous industries in the national economy, supporting more than 120,000 farmers and generating total sales of over €4.5 billion, with 2021 exports of approximately €3.2 billion.

Sarah: My work within MTI ensures that all novel results are appropriately assessed and an appropriate access strategy is determined and implemented. Novel results without commercial potential are published and freely available to all; results with commercial potential are made available for licensing to the industry parties that co-fund MTI. Licensing results can generate commercial benefits for both the industry and the market. Ultimately, the outcomes from MTI IP management can result in significant economic, social and environmental impacts.

What results have you seen? Have there been any broader industry changes related to your work?

Ruth: We have a unique working environment in which to appraise new, state-of-the-art technologies in automation and digitalisation. Our research outputs are being

Andrew Downes

Innovative, industry-backed research in genetics and digitalisation are driving clear improvement in the quality of Irish beef and sheep meat

licensed across the sector, bringing added value back to our research.

Charlene: The MTI consortium is trailblazing in how it has seen industry partners coming together and contributing data to tackle the sector-wide challenges we all face. This level of co-opetition at national scale in itself signals a broader change in the industry.

Can you describe your team's contribution to Teagasc?

Charlene: Teagasc has put in place all the necessary infrastructure for MTI to operate to a high standard, including providing access for MTI to highly skilled and experienced PIs in the organisation.

In return, MTI provides opportunity for Teagasc researchers to excel in world-class research through its unique level of industry collaboration, for example, through opportunities to explore large industry datasets and undertake factory trials to solve solutions at a scale not normally accessible to researchers.

Sarah: The learning gained through supporting MTI – and managing the IP emerging from it – has proven invaluable. Our work here helps inform exploitation pathways for emerging IP and digital innovation across the Teagasc research programmes and other Teagasc-led research centres, such as VistaMilk.

What are the team's values and principles?

Ruth: We support 'Teagasc Together' values, because the teams within MTI come from several departments and programmes and are bringing the individual skills and expertise to the common challenge. MTI is developing international collaboration links; alongside our patent applications and industry impact, this supports Teagasc goals and business plans.

Sarah: Teagasc's values are Fostering Respect, Striving for Excellence and Acting with Integrity. These are the guiding principles for me and my fellow team members. I believe they are a significant part of the reason our team works so well together and is so successful at supporting MTI achieving its objectives.

Charlene: As well as adhering to Teagasc's values, MTI is operationally managed according to the ISO 9001:2015 standard for quality management. MTI undertakes an annual audit to ensure ISO standard adherence. This process ensures clarification regarding MTI stakeholder roles and responsibilities, tracking and monitoring of the programme, risk identification and continuous improvement.

What are you proudest of as a member of the team?

Susan: The work is varied and challenging, and I enjoy working alongside such a variety of roles within different organisations. Although I don't have a research background, I believe that my back-office role is important to the project and helps MTI achieve its overall objectives.

Sarah: I am proudest of the trust and confidence placed in me – by both RPOs and industry collaborators – to oversee and address the IP aspects of MTI's remit.

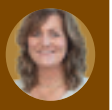
Charlene: The Irish meat sector is facing tough challenges, and I'm proud to be part of a consortium that is positively and meaningfully delivering research and innovation to tackle these challenges.

I also appreciate the unique opportunity to work with a range of Teagasc colleagues and departments, highly regarded PIs and industry partners, all of whom are outstanding and ambitious in their engagement and contributions. T

Meet the team

Sarah, IP Officer
"I'm proud to support MTI in identifying and developing significant IP."

Susan, Financial Controller
"I support MTI through financial guidance on all its research projects."



Ruth, Lead PI
"Our research allows industry to assess relevant, novel technologies."

Charlene, Programme Manager
"MTI provides researchers with an opportunity for world-class industry collaboration."

ACKNOWLEDGEMENTS

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Circular Food System

Diversification

Key challenges and opportunities in Ireland's plant-based sector were revealed in a recent stakeholder workshop, highlighting the potential for sustainable food production and the need for strategic interventions.

Planting the seeds

Globally recognised for its environmental, nutritional, and socioeconomic advantages, plant-based protein production and consumption is gaining traction. Ireland aims to position itself as a global leader in sustainable food production.

As a result, the Protein-I initiative, a DAFM-funded all-island research project, brought stakeholders together from diverse backgrounds to discuss the current state of the plant-based protein value chain.

Through collaborative discussions, stakeholders explored gaps, challenges, and potential business opportunities associated with the production and supply of ingredients for food use within the tillage sector. The increasing demand for plant-based protein emphasises the need for sustainable value chains in food supply networks, highlighting the importance of insights gathered from stakeholders in shaping the tillage sector.

Protein-I focuses on cereal crop production, initially targeting wheat and oats for food purposes. Desk-based research produced a preliminary value chain map, providing valuable insights into the different value chain stages. Teagasc and University College Cork (UCC) subsequently hosted an in-person stakeholder workshop, which was attended by 23 stakeholders with diverse knowledge of the Irish plant-based value chain.

Amanda Sithole, a Teagasc Walsh Scholar and PhD student at UCC, explains: "The workshop was designed to sense-check a preliminary value chain map created through desk-based research and to identify gaps, challenges, opportunities, and potential areas for improvement."

Workshop participants highlighted numerous challenges facing the Irish plant-based sector along its value chain, continues Amanda.

"A key challenge that emerged is the insufficient demand for suitable seed varieties tailored for the food market, due to a historical focus on the feed market and reliance on imported flour. Tillage farmers in particular face challenges in acquiring land, as they experience lower and uncertain economic returns compared to other farmers – particularly dairy farmers – when seeking available land for purchase or rental."

Additionally, agronomic challenges were emphasised by the participants, intensified by market demands – such as clean labelling and reduced inputs – and the policy drive to reduce input use, e.g. pesticides. To address the latter, stakeholders stressed the importance of implementing appropriate crop rotations and strategies for soil health and integrated pest management.

> **"A key challenge that emerged is the insufficient demand for suitable seed varieties tailored for the food market, due to a historical focus on the feed market and reliance on imported flour."**

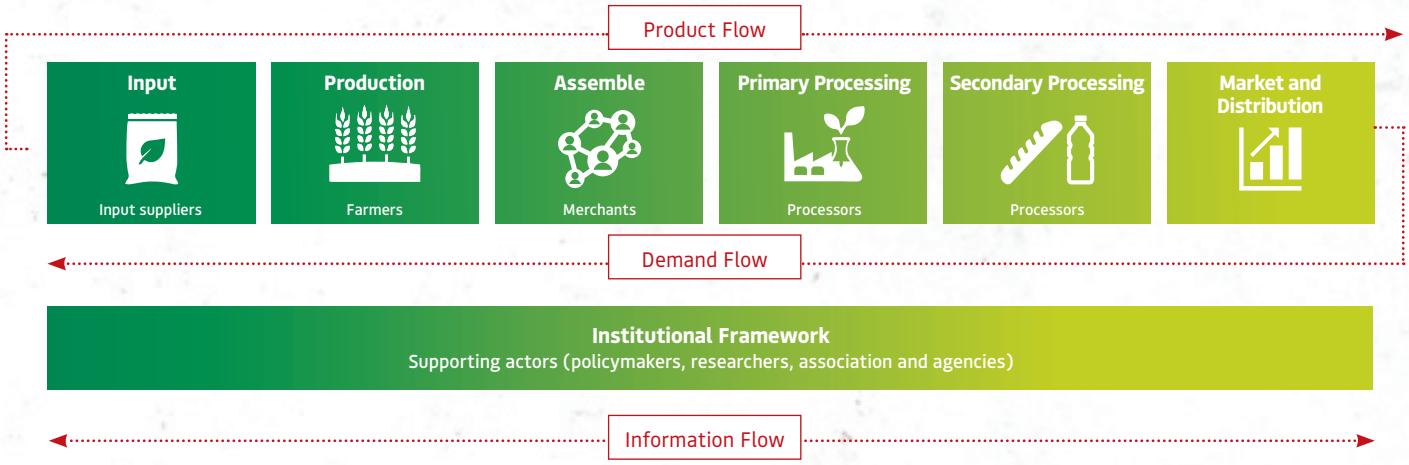
Merchants at the workshop shared the challenges they encounter in securing a consistent cereal supply, with issues relating to both quantity and quality required for food processing. Primary processing faces challenges due to limited investment in infrastructure, such as large-scale milling facilities.

Participants also identified gaps in other essential infrastructure, such as demonstration plants suitable for plant protein and related materials to support scale-up.

"Another significant challenge highlighted by workshop participants is the need to enhance industry agronomic knowledge related to food production. This challenge extends from farmers to advisors and is exacerbated by a shortage of graduates in the field," Amanda adds.

Attendees at a Teagasc/UCC-hosted stakeholder workshop met to assess challenges along the entire value chain of the plant-based sector

Researchers produced a preliminary value chain map, providing insight into the various stages of the value chain for plant-based protein



"The importance of market research to align Irish cereal attributes with diverse market segments was emphasised, highlighting a need for feasibility studies into ingredient and food product markets that offer the opportunity to deliver a price premium over feed."

Moreover, concerns were raised regarding policy instruments potentially favouring meat and dairy products over plant-based innovations, emphasising the importance of a balanced enabling environment.

Unlocking business potential

Despite the challenges, the workshop participants highlighted Ireland's potential to meet the demand for plant-based protein food products. They highlighted opportunities at both product and industry development levels.

The participants explored a range of possibilities, particularly focusing on wheat and oats, and extended to other cereals, such as legumes, Amanda says.

"They identified opportunities for food products such as soda bread, sourdough bread, pizza bread, oat beverages and sports drinks made from legumes. Additionally, they considered innovative products like barley protein flour and hybrid mixes of legume and wheat flour. Throughout, participants emphasised the importance of diversifying crops and planning rotations to produce these products."

Participants identified product development opportunities at both niche and mainstream levels. Niche products – differentiated by provenance-based quality attributes and sustainability benefits delivered through short food supply chains – have potential.

Exploring the industry's development further, the workshop participants recognised the potential to increase milling capacity with an emphasis on strategic local/regional locations.

These actions could pave the way for the establishment of domestic wheat-based food product value chains. In the broader tillage sector, promising prospects were identified, particularly in plant protein extraction and related materials, extending to raw materials for non-food packaging.

Amanda concludes: "As Protein-I, alongside projects such as U-Protein and VALPRO Path, is collaborating with stakeholders to understand the complexities of the Irish food system, the plant-based sector emerges as a significant opportunity for sustainable production and consumption. Additional research will be undertaken to develop pathways to support its development." T

FUNDING

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Circular Food System

Increase Carbon Capture

Grass - the green gold

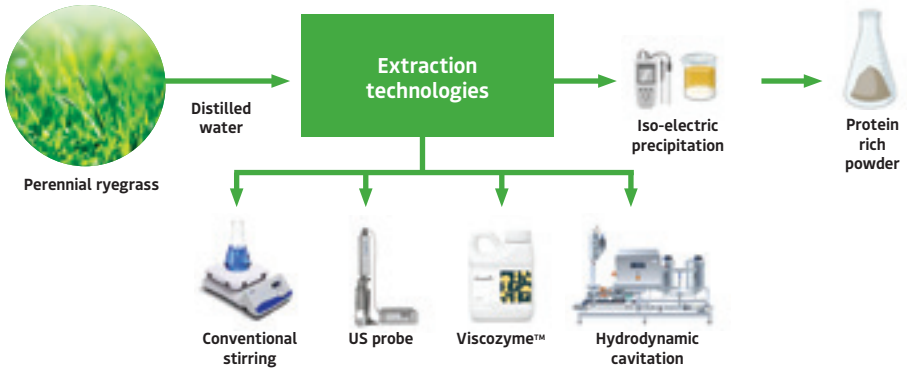
Ireland is renowned for its abundant grass growth. Not only is grass the main source of feed for pasture-based animals, Teagasc scientists have demonstrated its potential for use in a multitude of products from pharmaceuticals to packaging.

We are seeing demand for sustainable food protein sources skyrocket, driven by issues of an escalating global population, increased urbanisation, rising numbers of people affected by protein malnutrition, and stern environmental concerns. Demand for dairy, animal and fish proteins is rising constantly, and global demand for animal proteins is expected to double by 2050.

However, animal rearing is associated with high greenhouse gas (GHG) emissions and increased land and water usage, as well as recent concerns of increased health risks and ethical and religious disputes linked to animal slaughtering. Hence, the shift has been towards embracing alternative sources of protein.

Cultivating high-protein crops such as soy is resource-intensive, demanding significant water usage and a heavy reliance on fertilisers. Grass, on the other hand, grows almost anywhere and requires minimal water, fertiliser or pesticides. If cultivated, grass can be grown abundantly and harvested with relatively low costs. Using locally grown grass for protein production can reduce transportation costs and support local economies.

Extraction technologies for protein recovery from perennial ryegrass



Extraction technologies implemented for protein recovery from perennial ryegrass

Teagasc

From pasture to plate

Grass may be typically perceived as a low protein source varying in protein content between 16-28% when dried, compared to legumes having a protein content of 20% to 40% on an average. Freshly harvested grass, which contains nearly 80% moisture, has a much lower protein content of around 5% compared to its dried form. Grass also has a high content of complex and rigid polysaccharides, namely cellulose, hemicellulose and lignin. Rahel Suchintita Das, Research Officer at Teagasc Ashtown, explains that all these factors raise questions about the feasibility of extracting protein from grass.

"This is where our research outcomes offer a promising solution. At Ashtown's Food Research Centre, we harvested perennial ryegrass and processed it directly for protein extraction. This allowed us to explore the possibilities of eliminating the need for energy-consuming pre-processing preservation steps, such as drying."

The research team also aimed to develop a clean and green extraction process, switching from the use of harsh and detrimental chemical solvents to simple plain water as the solvent for extraction. To achieve this, they efficiently leveraged the cutting-edge technologies of ultrasonic cavitation at lab scale and hydrodynamic cavitation at the pilot scale. This allowed them to mechanically break down the cell walls, along with the tough polysaccharide network in the grass tissues, to help extract the protein in water.

"We also explored the potential of a multi-enzyme blend to hydrolyse the polysaccharides and loosen the matrix to enable enhanced protein diffusion. The proteins solubilised in water were recovered by iso-electric precipitation technique," Rahel continues.

Ultrasonic cavitation for 20 minutes delivered 53% protein content, hydrodynamic cavitation for 30 minutes yielded 47% protein content and enzymatic hydrolysis for 3 hours resulted in 61% protein content in the final protein product. In contrast, a conventional method of only mechanical stirring led to 56% protein content in the precipitate in 18 hours.

20 minutes
of ultrasonic cavitation of grass tissues delivered 53% protein content

A zero-waste approach

Rahel explains that the resultant proteins, obtained through extraction using the advanced techniques, displayed a beneficial amino acid profile and significant water and oil-holding capacities along with noteworthy emulsification and foaming properties: "Exploiting these properties opens the door to using grass proteins in formulating a variety of food, feed, nutraceuticals, pharmaceuticals, cosmeceuticals and also biodegradable packaging materials."

> **"[Extraction techniques] open the door to using grass proteins in formulating a variety of food, feed, nutraceuticals, pharmaceuticals, cosmeceuticals and also biodegradable packaging materials."**

Potential high-value products include: alternative protein based milks, yoghurts, spreads, cheese; bakery and extruded products; salad dressings; protein shakes; protein-rich snacks; ready-to-prepare mixes; as binders, extenders and fillers in meat-based products and meat analogues; and films, gels and encapsulates.

Rahel adds that this research has implications beyond directly developing products containing grass proteins. "The solid biomass residue remaining after protein extraction is being targeted towards further use in recovering dietary fibre. The liquid waste streams are being investigated as substrates for microbial propagation and fermentation to produce bioactive compounds, micro-nutrients and bio-stimulants."

Ultimately, this cascading approach for complete utilisation of the grass and its processing side streams holistically paves the way for the creation of a zero-waste sustainable bio-refinery, she concludes.

"So, next time you're lying in a field, contemplate this: beneath you is a sustainable, nutritious, and downright revolutionary protein source. It's time to think outside the (cereal) box and identify the green gold. Embrace it, and you might just find the future of food under your feet." T

FUNDING

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Empowering postdocs: Unlocking career potential

Teagasc's Post-Doctoral Development Programme is helping scientists unlock their career potential. We meet some of the Fellows and find out how they have benefitted from the programme.

Embarking on a postdoctoral journey can be both exciting and challenging. Teagasc's Professional Diploma in Researcher Development, launched in September 2022 in collaboration with University College Dublin (UCD), provides postdoctoral researchers with the skills and knowledge needed to advance their careers. This 30-credit, Level 9 qualification is designed for Postdoctoral Fellows (PD Fellows) to complete while carrying out their postdoctoral fellowship at Teagasc, offering them the tools to thrive in diverse career paths.

Jane Kavanagh, Head of Research Development and Walsh Scholarships, explains, "The diploma equips participants with a vital mix of research, leadership and professional skills that are essential for success in both academia and industry. For researchers eager to push their careers forward, this programme offers the perfect opportunity to combine research with career development."

Holistic approach to growth

The Professional Diploma is structured around four key pillars: Research Skills, Professionalism and Communication, Leadership and Management, and Career Development. These pillars ensure participants develop a well-rounded skill set, helping them grow not only as researchers but also as future leaders in their fields.

The programme is led by UCD's Julie Dowsett and managed by Teagasc's Jane Kavanagh and Ann Kane. With three annual registration periods (January, May, and September), PD Fellows can begin the programme at the registration date closest to when they commence their fellowship. The diploma can be completed over 12 or 18 months, depending on the Fellow's contract length, and integrates easily into their existing work schedules.

Currently 55 PD Fellows are enrolled in the

"The diploma equips participants with a vital mix of research, leadership and professional skills that are essential for success in both academia and industry."

Mohammad Mohammadrzei (second from right) says that Teagasc's postdoc programme enhanced his project management and leadership skills

Andrew Downes

programme, all of whom are completing the diploma alongside their research activities at Teagasc.

Flexibility and real-world application

The diploma's flexible structure allows participants to balance professional development with their postdoctoral responsibilities, Jane continues.

"The course offers a mix of live sessions, pre-recorded materials and interactive workshops, delivered online and – where possible – in person at Teagasc locations. This hybrid model enables PD Fellows to engage with the material at their own pace."

The assignments focus on practical applications, from enhancing CVs to creating professional development plans. Each task is designed to consolidate the skills and knowledge gained, helping participants apply what they learn directly to their career development. Regular tutorials ensure that PD Fellows have support throughout the programme.

Networking and career support

One of the programme's key benefits is the opportunity to network with peers from across Teagasc. This interaction helps the Fellows build valuable connections and exchange ideas. Additionally, the programme includes one-on-one coaching sessions with career specialists, allowing participants to develop tailored plans for their professional growth.

The programme also prepares researchers for leadership roles, with modules on leadership and team management designed to build the skills necessary for managing projects and leading teams. Whether aiming for a role in academia, industry or another sector, the skills learned will be essential for career advancement.

Why apply?

Teagasc's Professional Diploma in Researcher Development is an investment in the future of postdoctoral researchers. The programme not only provides participants with crucial skills but also helps them build networks and gain professional recognition, Jane concludes.

"With its flexible structure, practical focus, and expert support, it's the perfect stepping stone for postdoctoral researchers ready to take the next step in their careers. If you're ready to take that next step, apply for a postdoctoral fellowship at Teagasc and unlock your full potential."

Meet our recent graduates

Teagasc's Professional Diploma in Researcher Development has had a transformative impact on the careers of several postdoctoral researchers. Here, we showcase five graduates who have used the skills and knowledge from the programme to advance their research and professional trajectories.

Conor Bracken

Conor Bracken, now a Scientific Officer at the Environmental Protection Agency, found the Professional Diploma instrumental in refining his skills:

"The Professional Diploma covered many beneficial modules to further develop the transdisciplinary skills required for a research career.

"I enjoyed the structure of the module delivery, distilling large topics into useful information that could be directly implemented into our postdoc roles. The highlight for me was the range of expert speakers who passed on valuable insights and knowledge."

UCD

While at Teagasc, Conor's post-doctoral research focused on sustainable farming practices, specifically minimising nitrogen losses through improved soil fertility management.

Teagasc

Marie Conway

Marie Conway, an Assistant Lecturer in Nutrition & Physiology at Technological University Dublin, highlights the programme's ability to foster professional growth:

"The Professional Diploma provided learning opportunities in leadership, team management, science communication, and research career progression. It also allowed me to network with other postdoctoral researchers across Teagasc, expanding my network for future opportunities."

As a Teagasc PD Fellow, Marie worked on the SuHeGuide project, a collaborative research initiative to create sustainable and healthy dietary guidelines. Her background in human nutrition led her to develop solutions that respect biodiversity and reduce the carbon footprint of food. ▶

Teagasc

Shannon Gwala

Shannon Gwala, now a Maria Skłodowska-Curie Postdoctoral Fellow at the Moorepark Food Research Centre, works on the valorisation of mushroom proteins. She found the programme valuable in both her professional and personal development:

"Participating in the Professional Diploma provided me with tools to articulate and maximise the impact of my research.

"The UCD blueprint principles for supervision, taught in the Supervision and Mentoring course, were illuminating and will be valuable as I embark on new responsibilities requiring me to oversee students at various levels. On a personal level, it was fascinating to learn about my personality in terms of leadership styles and how they fit and apply in various scenarios."

Shannon's research focuses on protein-enriched food prototypes for older adults, improving their digestibility and texture.

New Decade TV

Rebecca Hall (right) with presenter Kathriona Devereux for an episode of RTÉ's *10 Things to Know About...*

Rebecca Hall

Rebecca Hall, a Research Officer with the Agricultural Catchments Programme, found the diploma highly beneficial for career advancement:

"The course was very well-planned, enjoyable, and informative. The modules covered a range of essential topics, including research development, leadership, and scientific writing. A notable benefit was the free sessions with a recruiter to improve my CV and professional profiles."

Rebecca's research during her postdoctoral fellowship focused on phosphorus analysis in soils, contributing to better nutrient management practices.

Andrew Downes

Mohammad Mohammadrzaei

Specialising in agricultural extension and education, Mohammad Mohammadrzaei applied the programme's lessons to enhance his research's impact:

"Participating in the Professional Diploma programme during my post-doc, I enhanced and applied research project management skills such as time management, leadership, and stakeholder mapping. I also learned how to effectively utilise various communication channels provided by Teagasc to maximise the impact of my research."

Now a Behavioural Science Research Officer at the Teagasc Climate Centre, Mohammad's research focuses on behaviour change and decision-making related to adaptation and mitigation strategies. T

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A collaborative approach

Words by: Dale Crammond, Director of Meat Industry Ireland

Collaboration across the meat processing industries ensures that Ireland maintains a competitive edge in a fast-paced, high-value global market.

The establishment of Meat Technology Ireland (MTI) in 2016 was of critical importance to the meat industry, being the first industry-led innovation programme on the island where the needs of the industry are embedded in the specific objectives of the initiative.

Processors from Meat Industry Ireland (MII – the Ibec sector association which represents the primary beef, pork and lamb processing facilities) have been actively and enthusiastically engaged since the outset, working closely with Enterprise Ireland, Teagasc and the wider research community to deliver tangible benefits for the industry. This interaction has led to agreement on an exciting list of relevant projects that match the opportunities available in the marketplace.

The result of this collaboration is a centre with excellent potential to address some of our challenges, capitalise on opportunities and ultimately deliver growth for the beef and sheepmeat sectors. Now in its second phase of research, we have already seen the benefits, such as: genetic improvements, which have developed improved quality and consistency of raw material supply, and delivered a suite of health and nutrition characteristics of meat; packaging to increase shelf life; improved meat-eating quality; and a visionary approach, looking to the factory of the future. Technology developments and innovation are critical across all industries and the meat industry is no different.

The beef and sheepmeat sectors make an enormous contribution to rural Ireland, supporting 100,000 farm families. The sector supports 25,000 jobs in processing with large multiplier effects, providing prosperity to rural economies across the country. The meat sector has grown into a modern, efficient, outward-looking and forward-looking range of businesses, recognised internationally for the quality of its products. Its success is even more noteworthy given its dependence on exports into markets that are demanding and challenging, in which they face stiff competition from other large suppliers, with significant economies of scale. The sector had a phenomenal performance in 2023, with beef and sheepmeat exports valued at €2.7bn and €440m, respectively.

As a processing industry, we must never forget what we do, and that is working with our farmer suppliers to produce high-quality, nutrient-dense products for the global consumer. In a world where sustainability tends to dominate the narrative, food security cannot be forgotten.

Collaboration is key and MTI is a great example of what can be achieved when people work together. I want to recognise and acknowledge the close co-operation with Teagasc as host institute of MTI, and indeed the other participating research organisations. The outputs of MTI continue to be an important enabler for further developing Irish beef and sheepmeat exports, meeting marketplace requirements and growing value. Our reputation for product quality and safety are well renowned all over the world, and MTI will continue to provide new opportunities into new markets. I know this is another key pillar within MTI's work programme, and I wish the MTI team and the wider research base continued success.

Representatives from MII and MTI at the annual MTI conference

John Ohle

PMA-MAP-based packaging solution for fresh horticultural produce

Circular Food System

Technology

- Novel packaging solutions for soft berries and herbs, based on perforation mediated active modified packaging (PMA-MAP), developed at Teagasc.
- Have led to a further 10 days shelf life extension for strawberries and further 5 days shelf life for hydroponically grown basil when compared to conventional packaging.
- Through this tailored packaging solution, fruit and herb producers can further extend their products shelf life, reducing associated food loss/waste, while exploiting circular economy principles.

Unique Selling Propositions

- A three-step platform technology tailored for various horticultural produce, optimising shelf life and quality.
- The combined system includes gas flushing with optimised gas combinations, micro perforation of films and use of appropriate recyclable/biodegradable/compostable packaging material.

Development stage

- Validated at pilot scale, over two seasons, for strawberries (24kg in multiple punnets) and basil (12kg in multiple pouches).
- Shelf life of strawberries extended to 26 days and basil (hydroponically grown) to 10 days.

Opportunity to engage

We welcome engagement from the following industries to help drive commercialisation:

- Irish horticulture producers, e.g. berries and herbs.
- Packaging suppliers seeking sustainable innovative solutions.

clubfoto/istockphoto.com

Research funding

SFI Food Waste Challenge: LEAF NO WASTE, led by Technological University Dublin.

Teagasc PI: Shivani Pathania, Teagasc Food Research Centre, Ashtown.

For further information or opportunity to discuss, contact Miriam Walsh: engage@teagasc.ie or miriam.walsh@teagasc.ie

Facilitating predictive screening of food substrates prior to costly animal trials

Technology

- This *ex vivo* model of the human distal colon reliably mimics and predicts the impact that various food substrates are likely to have on the gut microbiome.
- This may help food industries better predict the impact of such foods in downstream clinical trials, essentially improving screening prior to investing in costly animal trials.

Unique Selling Propositions

- Overcomes occasional reliability issue associated with the micro-Matrix bioreactor platform as an *ex vivo* model of the human distal colon.
- Tackles the undesirable phenomenon of blooms of one genus or species, e.g. *E. coli*, which can interfere with accurate analysis of the predictive effects of various food substrates on the gut microbiome.
- Bridges the gap between *ex vivo* models and real life *in vivo* physiological situations.

Development stage

- An optimised Faecal Fermentation Media composition for conducting such *ex vivo* distal colon model experiments has been developed.

Opportunity to engage

We welcome engagement from the following industries:

- Food manufacturers screening test substrates in-house.
- Companies providing such services to food companies.

Research funding

Food for Health Ireland NEUROFOODS, funded by Enterprise Ireland and the Horizon 2020 programme under the Marie Skłodowska-Curie Grant, agreement no. 847402.

Teagasc PI: Paul Cotter, Teagasc Food Research Centre, Moorepark.

For further information or to discuss, please contact Miriam Walsh:
engage@teagasc.ie or miriam.walsh@teagasc.ie

The meat of the matter

Through hosting research centres like MTI, Teagasc puts Ireland in a unique position to tackle the increasing challenges facing the meat processing sector, explains Director of MTI, John Colreavy.

The challenges facing the meat processing sector are evident as consumers become increasingly informed and concerned about the impacts from livestock production on the environment.

In the space of a lifetime, the world's population has increased from three billion people to over eight billion. Today, the world faces the dilemma of feeding an ever-expanding global population while the effects of climate change – and the contribution agriculture makes to that change – are front and centre. The forecasts show that consumers will continue to choose beef and lamb as their protein of choice, not simply due to the exceptional nutritional benefits offered but because they enjoy consuming meat. The future is a world where consumer demand for meat protein is expected to grow as more communities around the globe continue to improve their living standards. However, that world will be characterised by jurisdictions that can demonstrate their sustainability credentials by means of independently validated scientific evidence. Therefore, there is a race to be the meat provider of choice in global markets that can demonstrate the best use of natural resources such as available land, feedstocks and water, while laying out a clear pathway to reducing further environmental impact. The social dialogue around the pros and cons of livestock product is over-simplified; the solutions required for agriculture to play its own part are varied and complex. Ireland has unique advantages associated with its agricultural systems by virtue of design, driven by a cultural heritage, legacy and commitment to being a food-producing nation.

> **"Ireland has unique advantages associated with its agricultural systems by virtue of design, driven by a cultural heritage, legacy and commitment to being a food-producing nation."**

The foundations needed to be at the head of the animal-protein competition were already being laid a generation ago. This is evidenced by the significant improvements in efficiency in our animal production systems since the 1970s, as well as the transformation of meat processing in the aftermath of BSE – from intervention commodity to market-leading, premium retail and food-service offering.

There is a need to rapidly build the evidence of the true carbon footprint of beef and lamb through the development of large datasets typically characteristic of MTI research. This also needs transparent, science-based rationale around the optimum strategies we should follow to achieve the ambitious reductions needed. In addition to an infrastructure that is the envy of the world – genetics, quality, animal traceability, food safety and animal welfare – the rapidly emerging digital world offers new toolkits to connect, harness and interpret the data from our food systems to drive towards continuous improvement in sustainability.

Given the work underway in MTI, and across Teagasc and other research institutions on the island, we can visualise a world where the methane/carbon footprint is measured, reduced and that reduction validated, enabled by the revolution in digital-processing power and storage. That same digital revolution will dramatically transform the efficiencies of the processing facilities tasked with extracting the maximum value and maximising the valorisation of waste of the precious raw material so carefully nurtured. T

ACKNOWLEDGEMENTS

MTI is funded by Enterprise Ireland under the Technology Centre programme in collaboration with beef processors Ashbourne Meat Processors, Liffey Meats, Dawn Meats, ABP Food Group and Kepak.

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.

A life worth living for animals

Event: WAFL 2024, Florence, Italy
Date: 30 to 31 August 2024

The 9th International Conference on the Welfare Assessment of Animals at Farm Level (WAFL) in 2024 was organised by Laura Boyle (Chair), Keelin O'Driscoll and Amy Quinn (Co-chairs) of the Teagasc Pig Development Department with the European Association for Animal Production (EAAP).

Most presentations focused on traditional welfare issues, such as reducing suffering in livestock through improved practices during transport, stunning, and slaughter. Laura Boyle says: "Studies discussed exhaustion in sheep and rest requirements for cattle on long journeys. A discussion on boredom in pigs highlighted the need to assess welfare beyond physical health, urging a holistic approach to animal welfare that includes mental well-being."

However, the conference also emphasised giving farm animals 'a life worth living', marking a shift from merely reducing suffering to promoting positive welfare. Laura explains: "A plenary talk highlighted the EU Cost Action LIFT's work on developing indicators of animal flourishing. Researchers shared videos of pigs swimming, goats playing, and other examples of animals thriving, demonstrating the concept of positive welfare. Another talk explored how understanding animal cognition can improve both welfare and farm management."

Overall, the work presented in the conference acknowledged the difficulty of improving welfare in current livestock systems due to economic pressures. The need to reimagine livestock systems in line with the 'One Health-One Welfare' framework was emphasised as the path forward for meaningful progress.

Delegates working towards positive animal welfare

Teagasc

Teagasc researchers enjoying the buzz at ENTO 2024

Teagasc

Keeping bugs at bay

Event: ENTO 2024, Liverpool University, United Kingdom
Date: 10 to 12 September 2024

ENTO is the Royal Entomological Society's annual conference, highlighting current research in entomology from across the world. ENTO 2024 covered all aspects of entomological research from insect behaviour to genomics.

Of particular interest to Teagasc Oak Park's Entomology and Virology group was the session on *Pests and natural enemies* and the session on *Monitoring and controlling crop pests*. Throughout ENTO 2024 there was a good discussion on Barley Yellow Dwarf Virus (BYDV), which is able to cause up to 80% yield losses in barley and is a key research focus of Teagasc. Indeed, the research conducted by Teagasc made valuable contributions to this discussion, through three oral presentations by Munir Mostafiz, Maximillian Schughart and Jack Perry (Walsh Scholar) focusing on, respectively, the life-history of grain aphids, insecticide resistance in grain aphids and the use of aphid monitoring tools to manage BYDV.

Alongside the oral presentations on BYDV, Teagasc also presented work on the use of fungi for aphid biocontrol (Simranjit Kaur), the threat of Bruchid Beetle to faba beans (Antoine Pichon) and use of mito-metagenomics to identify aphid species (Virgile Ballandras, Walsh Scholar).

Don't miss out on Teagasc's upcoming events! Join us at the Situation and Outlook economics event at Teagasc Ashtown on December 3 and visit the Teagasc stand at BT Young Scientist and Technology Exhibition at the RDS on January 9 to 11, 2025. Visit our website to see what we have planned: www.teagasc.ie

Circular Food System

Shades of rashers

Myglobin is the natural iron-containing pigment responsible for the colour of Irish bacon rashers. Depending on the exposure to oxygen and chemical additives like nitrites, the colour being displayed is in the shade of red ranging from pale pink to bright cherry red. This red shaded colour also highlights the marvellous marbling showing the lines of white intramuscular fat embedded on the meat that gives the nice flavour upon cooking. Technologies are being developed to make it more delightful for consumers as chemical additives are reduced and even removed.

Photo and description by:
Jan Roland Molina and
Cristina Botinestean
Teagasc project:
Development of Novel Nitrate/
Nitrite-Reduced and Nitrate/
Nitrite-Free Meat Products
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