

Research

Volume 12: Number 2. Summer 2017

RAMIRAN 2017

TEAGASC to host international conference

VISIONS OF RESEARCH

HPP TECHNOLOGY

BRACE FOR BREXIT

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The importance of EU research funding

Teagasc researchers and, more recently, its specialist advisers, regularly compete for EU research funding. For the current Horizon 2020 programme, Teagasc has a target to win €19m in funding awards, and we are making good progress towards that target. Apart from ensuring that Ireland maximises its share of Horizon 2020 funding to help offset Ireland's contribution to the EU, why is this important? In my view, the collaborations entered into are the key driver for seeking EU research funding. Research today is a very internationalised and collaborative endeavour. It is very important to collaborate to keep up with, and be involved in, the latest advances in research. Also, many of the research areas we are involved in are global issues such as food and nutrition security, climate change, and antimicrobial resistance, or they are research areas that are relevant globally, such as competitiveness, water quality, food processing, and genetic progress. Therefore, to solve them, we need a co-ordinated international effort. We are lucky to have the EU framework programmes to help organise this co-ordinated effort.

To help build collaborations that will successfully win EU funding, what can we do? Individual researchers can avail of opportunities to build collaborative networks through attendance at conferences, participation in COST actions, and networking with international colleagues. At an organisational level, one of the most important actions we take is to get involved in ERA-NETs. Teagasc contributes funding to several ERA-NETs, most notably ERA-GAS, SusAn, ICT-AGRI and C-IPM. The Department of Agriculture, Food and the Marine also contributes funding to several ERA-NETs, and this Irish funding allows Teagasc and other Irish researchers to participate in collaborative projects.

Through these collaborations, we are able to direct greater resources at the research questions than any country could individually and, particularly, a small country like Ireland. We get first-hand access to the full results of the projects, not just the parts that we conduct ourselves. So the €19m of funding we hope to be awarded in Horizon 2020 might be part of projects with a total value of €190m, and we have first-hand access to the full results of this investment, as well as the enhanced capability of our researchers from working with top-quality international collaborators.



Frank O'Mara
Director of Research

An tábhacht a bhaineann le cistiú taighde ó AE

Téann taighdeoirí de chuid Teagasc agus, níos déanaí fós, na comhairleoirí speisialta dá chuid san iomaíocht go rialta le haghaidh cistiú taighde ón Aontas Eorpach (AE). I gcás chlár reatha Fhís 2020, tá sé mar sprioc ag Teagasc suim €19m a bhuachan i bhfoirm dámhachtaí cistiúcháin. Tá dea-dhul chun cinn á dhéanamh i leith na sprice sin. Cén fáth a bhfuil sé sin tábhachtach, seachas maidir lena chinntiú go mbainfidh Éire lánairbhe as a sciár de chistiú Fhís 2020 ar mhaithe le ranníocaíocht na hÉireann le hAE a fhritháireamh? I mo thuairim féin, tá na comhthionscadail a dtéitear ina mbun ar an bpríomhthoisic maidir le cistiú taighde ó AE a lorg go rathúil. Rud an-chomhoibríoch an-idirnáisiúnaíche is ea an taighde sa lá atá inniu ann. Tá sé rithabhachtach go n-oibrímid le chéile chun coinneáil suas leis an dul chun cinn is déanaí sa taighde agus go mbíonn ról againn sa dul chun cinn sin. Ina theannta sin, is saincheisteanna domhanda iad formhór na réimsí taighde lena mbímid ag plé, mar shampla, an tslándáil bia agus cothaithe, an t-athrú aeráide agus an fhrithsheasmhacht in aghaidh ábhair fhrithmhiocróbacha. Bíonn ábharthacht domhanda ag baint le réimsí eile taighde, mar shampla, an t-iomaíocht, cáilíocht an uisce, próiseáil an bhia, agus an dul chun cinn géiniteach. Má táimid chun na saincheisteanna sin a réiteach, mar sin, is é iarracht chomhordaithe idirnáisiúnta a theastaíonn uainn. Tá an t-ádh linn creatchláir AE a bheith ar fáil dúinn chun cabhrú linn an iarracht chomhordaithe sin a eagrú. Cad is féidir linn a dhéanamh, áfach, chun comhthionscadail a fhorbairt a n-éireoidh leo cistiú ó AE a bhuachan? Is féidir le taighdeoirí aonair leas a bhaint as deiseanna chun líonraí comhoibríocha a fhorbairt trí fhreastal ar chomhdhála, trí pháirt a ghlacadh i ngníomhartha de chuid COST (an Comhar Eorpach san Eolaíocht agus sa Teicneolaíocht) agus trí líonra le comhghleacaithe idirnáisiúnta. Ar leibhéal eagraíochta, tá ár rannpháirtíocht i dtionscadail ERA-NET ar cheann de na gníomhartha is tábhachtaí a dhéanaimid. Cuireann Teagasc cistiú ar fáil do roinnt thionscadail ERA-NET, go háirithe ERA-GAS, SusAn, ICT-AGRI agus C-IPM. Cuireann an Roinn Talmhaíochta, Bia agus Mara cistiú ar fáil do roinnt thionscadail ERA-NET freisin. Is mar thoradh ar an gcistiú Éireannach sin a chumasáítear do Teagasc agus do thaighdeoirí Éireannacha eile páirt a ghlacadh i dtionscadail chomhoibríocha. Trí na tionscadail sin, is mó fós na hacmhainní a fhéadaimid, mar thír bheag, a dhírú ar cheisteanna taighde ná mar a d'fhéadfadh aon tír a dhéanamh léi féin. Faighimid rochtain phearsanta ar lánorthaí na dtionscadail, agus ní na torthaí ar na codanna a stiúraimid féin amháin. D'fhéadfadh, mar sin, gur mar chuid de thionscadail a bhfuil luach iomlán €190m orthu a d'úsáidfidh an cistiú €19m a bhfuil súil againn é a fháil faoi Fhís 2020. Gheobhaimid rochtain phearsanta ar lánorthaí na hinfeistíochta sin freisin. Chomh maith leis sin, chuirfeadh ár dtaighdeoirí arís eile lena gcuid inniúlachtaí ó bheith ag obair le comhoibríthe idirnáisiúnta den chéad scoth.

Frank O'Mara
Stiúthóir Taighde

Making science for all



Ciara O'Donovan presented her research at the final of the Science4all competition in UCC.

A young Teagasc researcher, Ciara O'Donovan, qualified for the final of Science4all, which took place in UCC recently. Science4all is a science communication competition, now in its 13th year, which challenges young scientists to share the excitement of their research with the general public in an easily understandable manner, without using jargon. Originally from Clonakilty in Co Cork, Ciara graduated with an honours BSc in Nutrition and Health Science from Cork Institute of Technology in 2015,

and is currently carrying out research for a PhD based in Teagasc in Fermoy. Her presentation was entitled "Never travelling alone": the impact of travel on the gut microbiota, and explained her research on the impact of travel on the gut microbiota. Ciara studies the bacterial populations of individuals at home, and then during travel to between one and four different destinations. She hopes that her research may lead to interventions to prevent people suffering digestive issues when they travel. On being selected for the final, Ciara said: "I entered the competition as I really enjoy participating in activities that allow me to interact with the general public and tell them about science and research. From participating in this competition, I feel like I have gained a lot of confidence in my ability to present my work, which I believe will help me in communicating my research in the future, not only to a general audience but also to the scientific community".

Crops on social media



The Virtual Irish Centre for Crop Improvement (VICCI) has launched its new website and Twitter account (@CropImprovement). VICCI brings together the most active crop and plant science research groups in Ireland to generate a critical mass of knowledge, expertise and resources that will allow us to address the key challenges facing tillage and forage crop production in Irish agriculture. Ireland has a very high yield potential for crops, but the same climate that bestows high yield potential also demands high levels of external inputs and associated costs. One of the most cost-effective strategies for reducing inputs, while maintaining or even increasing yields, is to continue to breed improved varieties of crop

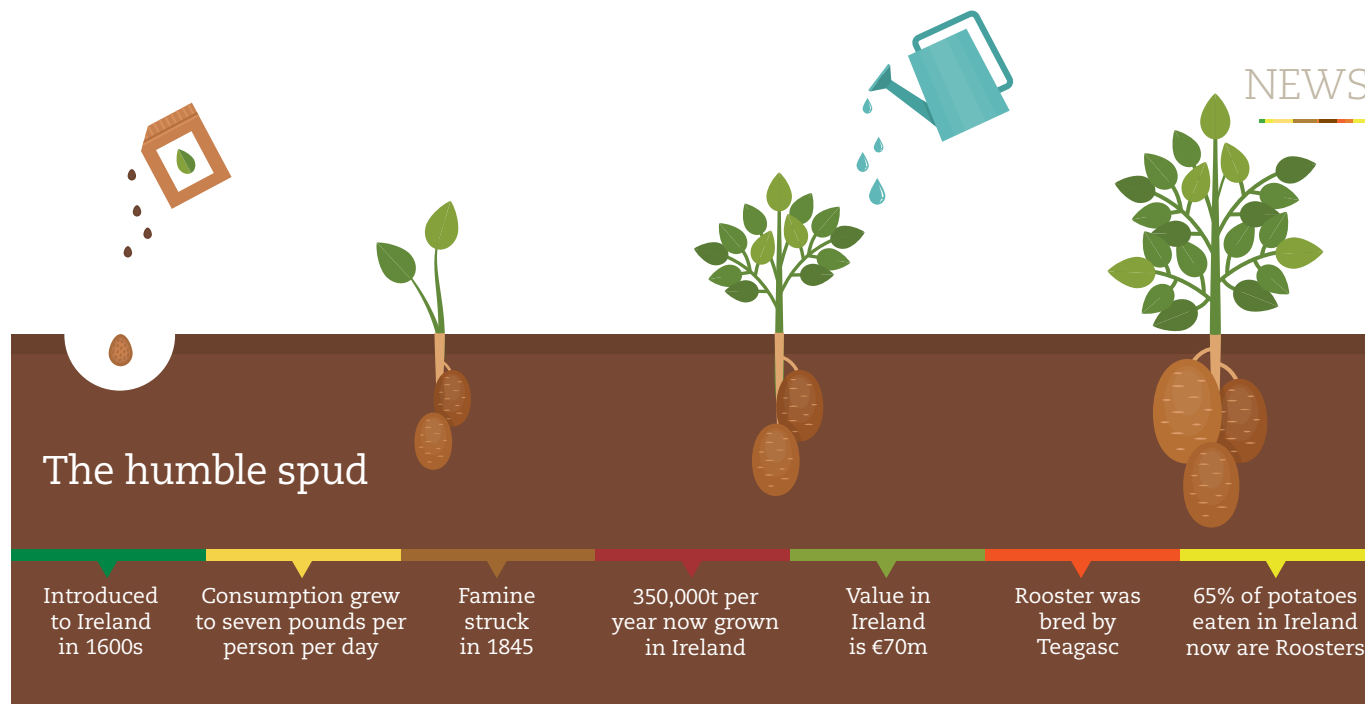
plants. Recently however, genetic gain for yield has stagnated in many crops, especially highly productive cereals. In addition, while genetic improvement of some species has resulted in major yield increases, the rate of genetic gain in others has been less than optimal due to complex genetics or other constraints. In the context of factors such as climate change and an increasing global population, these trends are worrying. However, these challenges have arisen against a backdrop of huge advances in the area of plant science, offering knowledge-led solutions that will secure sustainable productivity in Irish agriculture in the future. Built around a team of 16 of Ireland's leading crop, plant and agricultural scientists from Teagasc, UCD, NUIG, NUIM and TCD, VICCI is focusing on four challenges in Ireland's most important crops, namely cereals (wheat, barley, oats), perennial ryegrass, potatoes and beans. For more information, log on to www.vicci.ie.

Irish Laboratory Awards – Teagasc winners

Congratulations to Teagasc winners at the Irish Laboratory awards 2017, which took place in Dublin on May 25. Paul Cotter's Vision 1 laboratory won Food Laboratory of the Year and also Commercial Laboratory of the Year. Catherine Stanton was announced as Laboratory Scientist of the Year and Fiona Crispie was also nominated in this category.



Pictured receiving the Commercial Laboratory of the Year Award from Matt Moran, Director, BioPharmaChem Ireland (second from right) are (from left): Laura Finnegan, Grace O'Callaghan and Fiona Crispie (Vision 1 Food Research Laboratory – Teagasc Fermoy).



New Head of Rural Economy and Development Programme

Teagasc has appointed Kevin Hanrahan as Head of its Rural Economy and Development Programme. Based at the Teagasc, Mellows Campus in Athenry, Kevin will lead Teagasc's national economics and rural development research and knowledge transfer programme.



Kevin qualified in economics from Trinity College Dublin (TCD) followed by a Master's degree at TCD and a doctorate in agricultural economics from the University of Missouri, Columbia, USA. He began his professional career as a tutor in economics and statistics in the economics department of Trinity College before joining Teagasc as a Research Officer in 1995. His research in agricultural economics has been largely based on the development and use of partial equilibrium models of agricultural markets (FAPRI-Ireland, AGMEMOD) to evaluate the economic impact of potential policy changes. The use of the FAPRI-Ireland model has changed the agricultural policy reform process in Ireland.

Speaking after his appointment, Kevin said: "Teagasc's Rural Development Programme is recognised as a primary source in Ireland of research-based information, and socio-economic and geospatial analysis of the Irish agri-food economy and rural space. We will continue to work to improve the competitiveness of the agri-food sector, support sustainable farming and the environment, encourage the diversification of the Irish rural economy and enhance quality of life in rural Ireland".

Meat Technology Ireland Launched



Pictured at the launch of Meat Technology Ireland were (from left): Minister for Agriculture, Food and the Marine, Michael Creed TD; John Malone, Chairman, Meat Technology Ireland; Minister for Jobs, Enterprise and Innovation, Mary Mitchell O'Connor TD; Teagasc Director Gerry Boyle; Enterprise Ireland CEO Julie Sinnamón; and, Teagasc Chairman Noel Cawley.

Meat Technology Ireland (MTI), a strategic research and innovation base in beef and sheep meat processing in Ireland, was launched recently by Minister for Jobs, Enterprise and Innovation, Mary Mitchell O'Connor TD, and Minister for Agriculture, Food and the Marine, Michael Creed TD. MTI is a new industry-led initiative with significant funding from Enterprise Ireland that will create a 'one-stop shop' for meat processing research and technology. The €8.1m five-year research and innovation programme has been developed by industry and is co-funded by Enterprise Ireland and a consortium of nine beef and sheep meat processing companies. MTI is hosted by Teagasc at its Ashtown Food Research Facility in Dublin with DIT, DCU, UCC and the Irish Cattle Breeding Federation involved as research providers.

Royal Society honours Teagasc researcher

Brijesh Tiwari, a Principal Research Officer in the Food Chemistry and Technology Department at Teagasc Food Research Centre, Ashtown, has been admitted as a Fellow of the Royal Society of Chemistry (RSC). Founded in 1841, the RSC is the largest organisation in Europe for advancing the chemical sciences.

The RSC partners with industry and academia, advises governments on policy, and promotes the talent, collaboration, innovation, information and ideas that lead to great advances in science. This

achievement of Fellow status recognises Brijesh's high level of accomplishment as a professional chemist and his outstanding contribution to the advancement of the chemical sciences. His area of research interest includes the application, chemical and biochemical aspects of novel technologies for various food and allied industries. He has published over 120 research articles and 12 books in the area of food science and technology. He is also an Editor in Chief of the *Journal of Food Processing and Preservation*.

Gut scrum – the rugby microbiome team



From left: Paul Cotter, Orla O'Sullivan and Wiley Barton, who are carrying out research into the gut microbiome of elite athletes.

The gut microbiome (microorganisms that reside in the gut) of professional athletes is distinct from that of the general public both functionally (what they do) and metabolically (what they produce). So say scientists at the Science Foundation Ireland-funded APC Microbiome Institute and Teagasc, together with collaborators at Imperial College London, who have taken their research on the microbiome of professional rugby players to a whole new league. The study was recently published in the prestigious scientific journal *Gut*. The research was funded by Science Foundation Ireland.

Septoria conference

A conference on Septoria disease in wheat took place on Wednesday, March 22, organised jointly by Teagasc, The Department of Agriculture, Food and the Marine, and the *Irish Farmers Journal*. The conference was officially opened by Andrew Doyle TD, Minister of State at the Department of Agriculture, Food and the Marine.

Speaking at the opening, Minister Doyle said: "I would like to affirm my Department's commitment to the arable sector by highlighting the fact that we have invested significant funding into primary crop research, integrated pest management and other related topics".

Head of the Teagasc Crop Science Research Department, John Spink, said: "The conference brought together Irish and European crop disease control experts to discuss the future control of Septoria, the most damaging wheat disease in Ireland and north western Europe. The conference focused on understanding resistance development and on promoting measures to help reduce disease pressure in crops". The conference was prompted by the discovery in 2016 by Steven Kildea, Teagasc plant pathologist, of Septoria isolates in the field with mutations conferring resistance to the SDHI group of fungicides; these fungicides have been the mainstay of disease control since he discovered mutations affecting the triazole group of fungicides in 2009. This same resistance has since been found elsewhere in Europe. The need for more resistant wheat varieties was highlighted by Ethel White of the Agri-Food and Biosciences Institute Northern Ireland and Joseph Lynch, a postdoctoral researcher in Teagasc, who have been looking at the value of Septoria resistance in developing more sustainable production systems.

Researcher profile

Anne is an economist in the Agricultural Economics and Farm Surveys Department.



She specialises in production and farm-level agricultural economics research. Her research interests include economics of land use, with particular interest in the impact of policy/taxation drivers on decisions in relation to succession, inheritance and land mobility. She designed and developed a hypothetical model to compare potential income streams under various policy/agricultural conditions. One of her main responsibilities on joining Teagasc

was working on the Teagasc National Farm Survey (NFS), the official source of statistics on farming in Ireland, fulfilling Ireland's statutory requirement in the provision of data to the European Commission. She has been one of the key authors of the NFS Annual Report for over a decade, and the management of the NFS database and provision of analysed data for agricultural economic and rural development research projects is an important aspect of her role.

Anne played a key role in project managing the redesign and modernisation of the NFS IT system/database, which has facilitated more timely and efficient NFS data collection, data mining and reporting on a more

flexible, robust platform. Her Master's dissertation examined the suitability of agri-environment schemes to unique landscapes, focusing on the Burren region. She has continued to retain a keen research interest in environmental/multidisciplinary projects, which included the BurrenLIFE project (which recently won an EU Green Award in Brussels), on which she was extensively involved and a member of the steering committee.

Anne is Irish representative on a number of international research consortia including the OECD Network for Farm-level Analysis, the agri benchmark Beef and Sheep Networks, and Global Forum. As Irish delegate, she has

also participated at EU Commission meetings and the Pacioli network on farm accountancy. She also participates on various national consultative and steering committees. Prior to joining Teagasc, Anne worked in the international financial services centre (IFSC), playing a pivotal role in setting up and managing a new fund management department for an international capital management company. She is a member of a number of professional bodies, including the Association of Chartered Certified Accountants (ACCA). Anne is actively involved in many artistic/design pursuits, plays various musical instruments, and is a former musical society participant.



Knowledge Transfer Ireland Impact Awards

John Halligan, TD, Minister for Skills, Training and Innovation, presented the KTI Awards. Pictured are all the KTI Impact Award winners, including Miriam Walsh, Tim Guinee and Mark Fenelon of Teagasc and Mary Keniry of Ornua.

Knowledge transfer success stories were celebrated at the recent Knowledge Transfer Ireland Impact Awards, where **TEAGASC** and Ornua took home the Licence2Market award.

The annual Knowledge Transfer Ireland (KTI) Impact Awards showcase success stories in knowledge and technology transfer carried out in Irish higher education institutions and publicly-funded research organisations (PROs). As well as recognising top performance in industry engagement and commercialisation of publicly-funded research, they celebrate the role of technology transfer offices (TTOs) in facilitating the formal knowledge transfer process. Along with supporting business and the research base to maximise innovation from State-funded research, KTI has a significant role in supporting Irish PRO TTOs, and these awards are an important means of publicising such knowledge transfer success stories and highlighting the role of the TTOs.

Teagasc award

The award categories included collaborative research, consultancy, Licence2Market and spin-out company, and the focus was on engagements with the most significant impact evident in 2016. Following a successful submission through its TTO to the Licence2Market award category, and selection as a finalist on the night, Teagasc and Ornua Co-operative were presented with the Licence2Market award, against competition from Trinity College Dublin and Dublin City University. This celebrates the significant impact from a commercial licence between Teagasc and Ornua executed in 2012, which granted Ornua exclusive rights to commercialise a Teagasc-patented technology, to manufacture and sell white cheeses in the Middle East. The licensed platform cheese-making technology, led by Tim Guinee at Teagasc Moorepark, represents a novel approach to cheese-making, without whey expulsion, and is based on reassembly of functional dairy powders into cheeses. Following Teagasc marketing, Ornua realised the

opportunity to secure significant new routes to market for Irish dairy produce, through the manufacture and sale of cheeses in countries with a shortage of fresh milk supply. Subsequently, a collaborative agreement with Teagasc was established to refine the technology, and a commercial licence secured for specific markets and cheese types. Significant economic impact was demonstrated in 2016, with Ornua opening its multimillion Euro cheese-manufacturing plant in Saudi Arabia and the launch of its first product. With plans to extend its product range in 2017 and to sell to extended Middle East and North Africa regions, Ornua forecasts strong sales growth over the next five years, while Teagasc will secure a royalty on such sales, as a return on State investment. This is a great example of successful technology transfer, with significant economic and societal benefits to both parties, the dairy industry and the economy. It also acknowledges the important role of the TTO in intellectual property management, formal licence negotiations and relationship management for such licences. For further details see: <http://www.knowledgetransferireland.com/News>.

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More than meats the eye

A meat co-products workshop hosted by the ReValueProtein project team took place in **TEAGASC** Ashtown Conference Centre recently.

The ReValueProtein project recently hosted a one-day event exploring the area of animal (non-dairy) protein extraction from meat processing co-products, for high-value applications. Meat processing co-products include fifth quarter items (such as hearts, livers, lungs and kidneys) and blood; however, the project also looks at other secondary streams such as exudates, brines and wash water, which are mostly marketed at low values or disposed of as waste, despite their rich composition and potential value.

Over 55 participants from industry, academia and State bodies attended. The day provided an opportunity to share knowledge and ideas for innovation in the Irish meat industry and ReValueProtein researchers from Teagasc, University College Cork, University College Dublin, National University of Ireland Galway, and Institute of Technology Tralee/Shannon Applied Biotechnology Centre were on hand to discuss the various aspects of their work. The opportunity afforded to attendees to interact with researchers and network with relevant industry players and funding agencies was certainly the highlight of the coffee and lunch breaks.

Manager of the ReValueProtein project, Liana Drummond from Teagasc, pointed out the relevance of the workshop for the Irish meat industry, as the content and quality of the programme aimed to encourage the meat industry to realise its potential, and to promote industry-academia interaction, exploring opportunities and supporting a more sustainable meat sector.

The workshop, which was chaired by ReValueProtein project co-ordinator, Anne Maria Mullen from Teagasc, included a combination of talks and practical demonstrations, covering a variety of topics on innovative technological approaches and applications of proteins in the food, beverage, cosmetics, health and biomedical engineering sectors.

The fifth quarter – products and processes

Guest speaker Charis Galanakis, Research & Innovation Director at Galanakis Laboratories in Greece, provided an overview of the barriers and opportunities in food waste recovery. Talking about the potential for co-products and waste valorisation, Dr Galanakis noted that despite many high-quality studies and patented methodologies, the number of commercial products is still limited. He highlighted the need for the use of flexible technologies, which could better cope with the variable nature of most waste streams, and the importance of establishing definite applications for products prior to development.

Darling Ingredients' nutrition, regulatory affairs and market access specialist Carine van Vuure provided an excellent overview of the global market for processed slaughter co-products, showing just how much can be gained from fully exploiting all parts of the animal carcass. In her opinion, natural ingredients (clean and clear labelling), convenient products (in terms of food preparation and portion control), and products to meet specific nutritional demands (e.g., healthy ageing) are the current key drivers for the food market, supported by sustainable and optimal valorisation of slaughter products: the 'nose to tail' approach.

The potential for harnessing value from meat co-product-derived proteins was further explored by Carlos Alvarez from the ReValueProtein project based at Teagasc Food Research Centre, Ashtown. He provided the latest results on several work packages, including improved blood quality separation, functionality tests in lung and heart protein extracts, protein separation and concentration in waste and side streams (glue water and brines), bioactivity of blood and lung protein powders, and the generation of bio-based films. Many of the recovered proteins displayed good emulsifying, gelling



and water/fat-holding capacity properties, essential properties for foods such as pâtés, sausages, gelatin-based foods and sports beverages. Ciara McDonnell, Research Officer in the meat research group in Teagasc Food Research Centre, Ashtown, covered the area of techno-functional ingredients for meat products, and the use of emerging technologies to improve products and processes. Among these, ultrasound (US) technology and high-pressure processing (HPP) are already attracting considerable interest from the industry, due to satisfactory results in improving the quality, efficiency, shelf life and safety of treated products.

Consumer perception

A thought-provoking talk was delivered by Mary McCarthy, from University College Cork Business School of Management and Marketing, on awareness and understanding of consumers' perceptions in relation to products originating from the fifth quarter, for a successful commercialisation strategy. She shared results and valuable insights from a recent consumer focus group's activity where the main identified challenges were related to consumer acceptability of ingredients from offal, as many are perceived as inedible. Mary emphasised the industry role in transforming "unacceptable" into "acceptable", which she suggested could be achieved by enhancing familiarity through availability and by communicating benefits in a clear and open manner.

Legislation

From the Food Safety Authority of Ireland (FSAI), John Matthews presented a brief account of the legislative environment regarding the use of animal-derived products for different applications, such as food

ingredients, feed, pet food, biomedical and nutraceutical applications. He highlighted the role of the FSAI in clarifying what can be a muddled area for new products and processes, but also pointed out the industry's responsibility in engaging with the FSAI, to ensure compliance with all applicable regulations.

Interactive demonstrations

Delegates had the opportunity to join a hands-on demonstration session at Teagasc Ashtown food product development unit, where sample materials from the ReValueProtein project were showcased. Blood separation and processing, bio-based films, techno-functional properties of heart and lung protein powders, gels and emulsions, as well as collagen biomaterials, such as sponges and fibres for wound repair and tissue scaffolding, were demonstrated and discussed.

Acknowledgements and further information

This work forms part of the ReValueProtein Research Project (Grant Award No. 11/F/043) supported by the Department of Agriculture, Food and the Marine (DAFM) under the National Development Plan 2007–2013 funded by the Irish Government.

All the workshop presentations are available on the publications section of the Teagasc website. For more on the ReValueProtein project see: www.revalueprotein.com.

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Visions of research and innovation

TEAGASC recently ran a photography competition for its staff and students. Some of the winning images can be seen here.

*Farming the uplands –
Karen O'Neill.*

Congratulations to the winner and runners-up of Teagasc's Visions of Research and Innovation image competition 2016. The aim was to find the most innovative and compelling images showcasing the range of research and innovation activities taking place across Teagasc. The overall winner was Karen O'Neill for her image 'Farming the Uplands'. The runners-up were: Deirdre Hennessy; Maria Hayes; Brian McGuinness; Dominika Krol; Leanne Roche; Dheeraj Singh Rathore; Wiley Barton; Jessica Werner; Catherine McCarthy; and, Giulia Bondi. The images were judged by a panel of Irish and international photographers. The images feature in a YouTube video showcasing excellent Teagasc research (<https://youtu.be/sl2XLON8XXc>) and many were included in a Teagasc Vision of Research 2017 calendar. Speaking about the competition, Frank O'Mara, Teagasc's Director of Research, congratulated all of the entrants and, in particular, the winner and runners-up. He said: "The images highlight the breadth of research and innovation activity undertaken by Teagasc staff, from students to senior researchers, and how a seemingly everyday image can be part of an exciting scientific investigation". The winning image shows a Scottish Blackface lamb grazing in the Caragh catchment and was taken during Walsh Fellow Karen O'Neill's work on the KerryLIFE project (www.kerrylife.ie). The agricultural system in the KerryLIFE project area features a low-intensity agricultural system of extensive mixed-livestock grazing, few agro-chemical inputs, and labour-intensive management practices. This creates a unique cultural and semi-natural landscape managed by

traditional farmers and their animals, and has made the Iveragh Peninsula a repository of a unique flora and fauna. Speaking of the winning image, judge Dr John Beeching, whose own photographs have been exhibited and published internationally, said: "While there was accompanying text for each photo, the ability of the photo to stand alone and communicate the theme was important". The next Visions of Research and Innovation image competition launched on May 9, 2017 and will close on October 2, 2017.

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Bottle brush blues –
Brian McGuinness.



FEATURE

One to many in vitro regeneration –
Dheeraj Singh Rathore.



Ruminating cow –
Jessica Werner.



Earth's colours –
Giulia Bondi.



Cow effect: mitigating greenhouse gases
from agriculture – Dominika Krol.



Bringing your work home with you –
Catherine McCarthy.

Factors affecting productivity of grass-based systems

Productivity of grass-based systems is dependent on achieving a balance between the competing objectives of high grass intake to maximise milk production per cow, and increased grazing intensity to maximise grass utilisation and milk production per hectare.

Within intensive grass-based systems, stocking rate (SR) is widely acknowledged as the primary lever of productivity. As SR increases, there is a linear increase in milk production per hectare. Additionally, higher SR systems are conducive to greater grass production and utilisation, and improved sward quality. While SRs on Teagasc dairy research farms are high (2.5-3.3 livestock units (LU)/ha) compared with the national average dairy farm (1.9LU/ha), high SR experimental comparisons provide important evaluations of the biological impact of intensification ahead of industry uptake. Although high economic breeding index (EBI) dairy cows are commonplace on many Irish dairy farms, little is known about the impact of intensification of farm systems on the performance of high-merit dairy cows. The appropriate cow for intensified grazing systems must be robust and fertile, and have the capability to convert scarce feed resources efficiently to high-value milk solids (MS). In this regard, the increased productivity of Jersey x Holstein-Friesian crossbreds (JxHF) over conventional Holstein-Friesian (HF) cows has been substantiated internationally. This is primarily due to their superior productive efficiency, fertility, and longevity. Notwithstanding these benefits, little is known about the relative impacts of increased SR on the performance of such genotypes. Consequently, the objective of this research was to compare the performance of high EBI HF and JxHF cows within a range of intensive grass-based production systems on both research and commercial farms.

Performance of HF and JxHF in commercial herds

A study was carried out to compare milk production and fertility performance of HF and Jersey purebreds, and JxHF cows on commercial spring-calving dairy herds in Ireland. A total of 24,279 lactation records

from 11,808 cows from 40 dairy herds over five years (2008-2012, inclusive) were available for analysis. JxHF first-cross cows produced 25kg more MS and had a 7.5-day shorter calving interval, compared with the average of the purebred parent breeds, which corresponds to additional profit of €162 per cow per lactation.



Teagasc researchers investigated productivity in three SR treatment groups.

Curtin's research farm experimental comparison

A follow-up experiment on Teagasc's Curtin's research farm investigated the productivity of a range of SR and breed combinations. Three SR treatment groups were investigated, defined in terms of bodyweight per hectare (kg BW/ha): low SR (1,200kg BW/ha); medium SR (1,400kg BW/ha); and, high SR (1,600kg BW/ha). Within each SR treatment, two breeds (HF and JxHF) were included in the experiment. The average EBI of the experimental herd was €142, ranking them in the top 1% of the

Table 1: Biological performance of the Curtin's herd (2013-2016).

Breed	Holstein-Friesian			Jersey x Holstein-Friesian		
Stocking rate	Low	Medium	High	Low	Medium	High
Bodyweight (kg)	510	492	483	467	466	443 (KG)
Milk production (kg)						
MS yield/cow	454	425	408	459	438	419
MS yield/ha	1,090	1,228	1,338	1,152	1,323	1,433
Production efficiency (kg)						
Daily intake/100kg BW	3.42	3.29	3.19	3.63	3.52	3.50
Daily MS/100kg BW	0.37	0.36	0.35	0.42	0.40	0.41

national dairy herd. The aim of the experiment was to identify the interaction between farm SR and breed on measures of the biological efficiency of spring-calving grazing systems. The low SR treatment was designed to allow each cow to express its milk production potential where grass supply was unrestricted, whereas the higher SR treatments investigated the potential response in performance per cow and per hectare to increased grazing intensity and grass utilisation.

Biological performance

Mean biological performance (bodyweight, milk production, and production efficiency) for each treatment for the four years (2013-2016, inclusive) of the experiment is presented in Table 1. MS yield per cow was greatest for low SR, intermediate for medium SR, and least for high SR. In contrast, MS yield per hectare was greatest for high SR, intermediate for medium SR, and least for low SR. As SR increased from low SR to high SR, dry matter intake and milk production per kg bodyweight decreased.

HF cows were on average 36kg heavier than JxHF cows. Similar to the commercial farm evaluation, MS production per cow and per ha was greater for JxHF cows. The JxHF cows consumed 8% more feed per kg bodyweight and produced 14% more MS per kg bodyweight than their HF contemporaries. Although the percentage of the herd in calf during the first six weeks of mating was greater for JxHF cows (73%) than HF cows (67%), there was no difference in overall pregnancy rate between the two breeds.

Grass production

Detailed grazing measurements were carried out to investigate the effect of SR and grazing intensity on grass production, utilisation, and quality. Although there was only a minor difference in overall grass production (Figure 1), increasing SR increased the proportion of grass utilised in the form of grazed grass.

Implications for industry

The results of the experiment highlight the benefits of increased SR in terms of greater grass utilisation and MS production per hectare. Additionally, the results of the experiment indicate that high EBI crossbred cows achieved superior milk production, feed efficiency, and fertility compared with HF contemporaries, within both commercial and research farm environments.

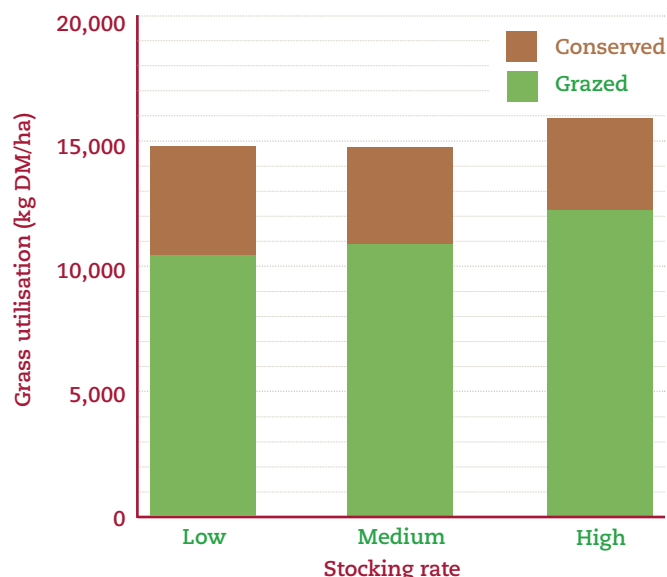


FIGURE 1: Grazed (green) and conserved (brown) annual herbage production (2013-2016).

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RAMIRAN 2017

TEAGASC will host an international conference on manure and organic residue management in September 2017. The following articles serve as a taster of some of the research to be presented.

The 17th international RAMIRAN conference is being hosted by Teagasc Crops, Environment and Land Use Programme, Johnstown Castle, Co Wexford, and takes place from September 4-6, 2017. This is the first time that this world-leading biannual conference will be held in Ireland. It represents international recognition of the Irish contribution to research, knowledge transfer and implementation of technologies and strategies that are contributing to this important component of sustainable farming systems. The conference will focus on cutting-edge knowledge, focused on improving the efficiency of manure and organic residue (e.g., composts, bio-solids) management. Recycling of Agricultural, Municipal and Industrial Residues in Agriculture Network (RAMIRAN) is a research and expertise network focused on agronomic and environmental issues relating to the use of these materials across a diverse range of farming systems and environments. This conference is the primary output of the network, which is held every two years.

Conference theme and sub-themes

The theme of RAMIRAN 2017 is 'Sustainable utilisation of manures and residue resources in agriculture', and this will be explored under five sub-themes (Figure 1).

Advances in technology

This section focuses on the latest innovations in manure and residue treatment, processing and management. It will include the development of new technologies for the generation of bio-based products (compost materials, paper, bio-based plastic and biochemical) and energy (bioethanol, biogas and heat) from manures and organic residues.

Crop nutrition

This theme will focus on the nutrient value of various manures and organic residues for both arable and grassland production, and their influence on crop yield and quality.

Gaseous emissions

Quantification and mitigation of gaseous emissions (greenhouse gases and ammonia) across the entire manure management chain (housing, storage, land spreading, grazing) will be covered under this sub-theme. Modelling of these emissions, including life-cycle assessment, will also be included within this sub-theme.

Soil and water quality

This sub-theme will include studies investigating the effects of manure and organic residues on nutrient losses to water, soil organic carbon, soil biological activity and biodiversity. The potential issue of contaminants and harmful pathogens arising in soil and water from the use of these materials in agriculture will also be addressed.

Adoption and impact

This sub-theme will focus on improving knowledge transfer from research to farmers related to manure and organic residue management, with experiences from different countries presented.

Conference programme

The conference programme includes an international panel of keynote speakers to address each of the sub-themes in a series of parallel paper and poster presentation sessions. There will also be a conference panel discussion and field trips for delegates. Over 190 presentations from experts from 35 countries, including many European states, the USA, Australia, China and Japan have been submitted to the conference. Over 250 delegates are expected to attend and will include policy makers, students, researchers, advisers and representatives of the agro-industry, government bodies and consultancy. Field trips during the conference will include a visit to the Teagasc Crops, Environment and Land Use Research Centre at Johnstown Castle, where the latest research and innovations on

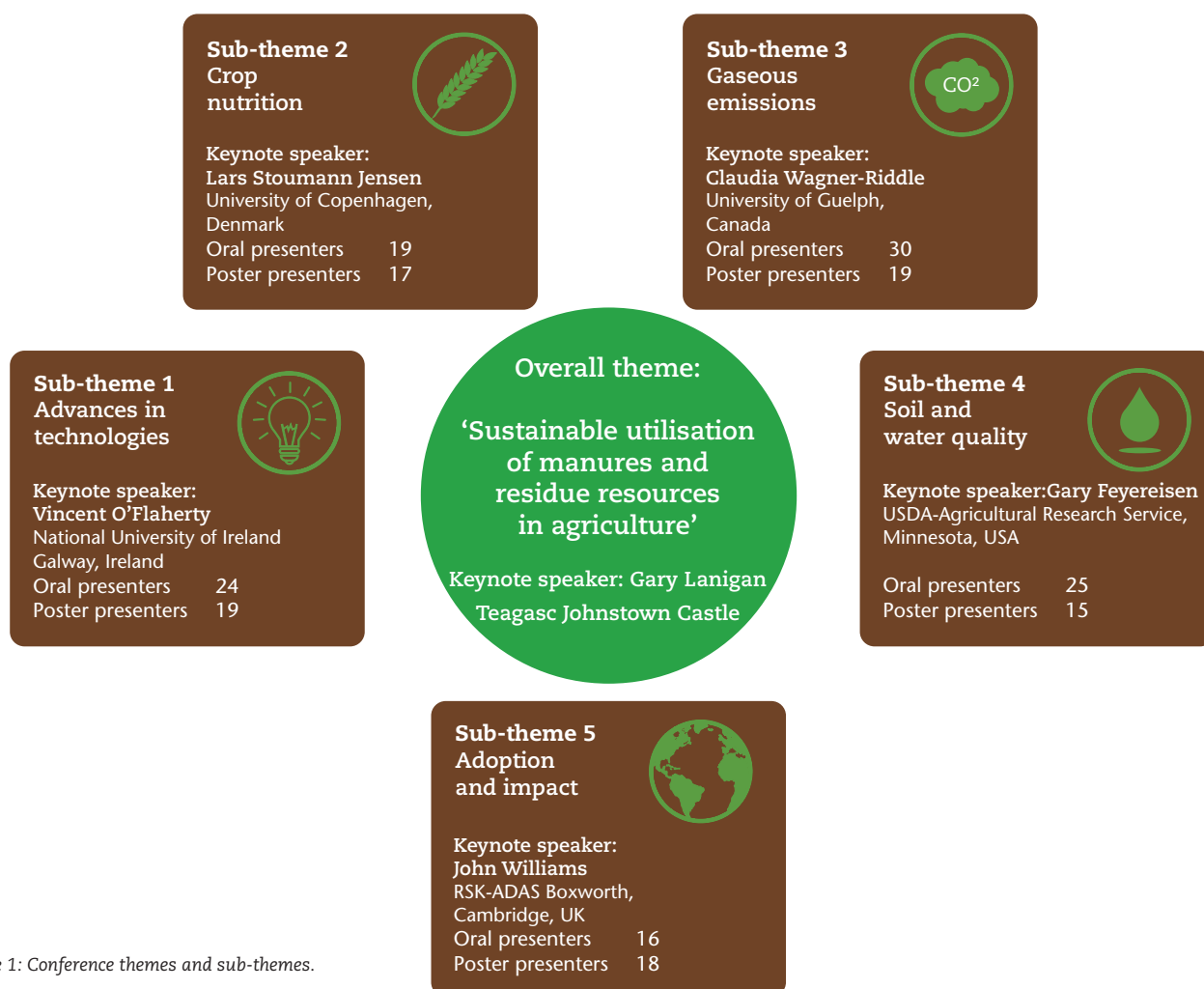


Figure 1: Conference themes and sub-themes.

manure and organic residue management will be on display. The conference will also include an extensive line-up of social events, which will provide a platform for further discussion and networking among delegates. These will include a gala conference dinner and Viking barbecue at the Irish National Heritage Park. The conference outputs and networking will provide Ireland with an improved platform to progress the development of strategies and technologies to address the significant challenges we face. These include developing economically-viable farming that protects and enhances the environmental media including water, air, soil and biodiversity, as envisioned in the Irish Government’s strategic plan for the development of the agri-food sector over the next decade, ‘Food Wise 2025’.

Registration

The conference takes place in the Clayton Whites Hotel, Wexford. Online registration will be open until August 28, 2017. Those interested in participating in the conference, and companies and organisations wishing to showcase their latest innovations and products on manure and organic residue management, should visit the conference website (www.ramiran2017.com), contact us at: ramiran2017@abbey.ie and follow us on Twitter: @RAMIRAN2017. The articles following this RAMIRAN 2017 preview provide an insight into some of the work that is currently being undertaken by Teagasc within the scope of the conference. These articles and much more work being conducted by Teagasc in

collaboration with other institutes will be presented at the conference. For more information on the RAMIRAN research network see: <http://ramiran.uvlf.sk>.

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LowAmmo: measuring ammonia in agriculture

TEAGASC researchers are working to quantify NH_3 emissions from agriculture with a view to meeting Ireland's National Emissions Ceilings Directive targets.

The ammonia challenge

Ammonia (NH_3) volatilisation from nitrogen (N) fertiliser and the manure management chain (housing, storage and land spreading) reduces N use efficiency and represents a substantial economic loss of N on Irish farms. Ammonia volatilisation also contributes to eutrophication and acidification of natural ecosystems and indirect emissions of the greenhouse gas nitrous oxide (N_2O). Ireland has committed to reducing national NH_3 emissions by 5% by 2030 compared to 2005 levels under the revised National Emission Ceilings Directive. Meeting these emission reduction targets along with achieving Food Wise 2025 targets presents a significant challenge for Irish agriculture, which accounts for >98% of national NH_3 emissions. The majority of Irish NH_3 research up to now has focused on emissions from slurry land spreading and fertiliser N applications.

LowAmmo

The 'LowAmmo' project was established in 2013 and aims to close some of the gaps in knowledge related to NH_3 emissions from Irish agriculture. The project's specific objectives are:

1. To quantify NH_3 emissions associated with cattle housing, cattle excreta deposition on pasture and yards, and slurry storage.
2. To quantify the abatement potential of NH_3 mitigation strategies for yards and slurry storage.
3. To develop models to estimate NH_3 emissions from Irish farms.

Developing ammonia emission factors for Irish cattle housing

NH_3 emissions from livestock housing are derived from two sources within the house: the housing floor; and, internal slurry storage tanks. Emissions arise from the mixing of excreted dung and urine in these two areas. Urea-N present in urine is rapidly hydrolysed to NH_4^+ and NH_3 by the enzyme urease, which is present in dung. This hydrolysis reaction also leads to an increase in pH, which favours the conversion of NH_4^+ (solid) to NH_3 (gas), thus leading to NH_3 emissions. During the project, NH_3 emissions were measured from four livestock houses in the south of Ireland over three winters (2014

to 2017) using passive flux samplers (Ferm tubes). The overall mean NH_3 emission factor (EF) from the four houses was 15.6g NH_3 -N/LU/d or 12.5% of total ammoniacal N (TAN) excreted. This is somewhat lower than the current EF of 31% of TAN excreted used in Ireland's national NH_3 inventory and highlights that NH_3 emissions from cattle housing in Ireland may be over-estimated.

Mitigation of ammonia emissions from concrete yards

Deposition of livestock urine and dung on concrete farmyard surfaces (collecting yards and livestock handling yards) has been identified as a significant source of NH_3 emissions, contributing up to 8% of Ireland's agricultural NH_3 emissions. Experiments were conducted on a livestock handling yard in August 2016 to investigate the effectiveness of different yard-cleaning options (pressure washing or scraping using a hand-held scraper) used at different time intervals (one hour or three hours after excreta deposition) at reducing NH_3 emissions. The NH_3 emissions were measured using wind tunnels.

Pressure washing at one hour was the most effective at reducing NH_3 emissions (91% reduction). Pressure washing at three hours reduced emissions by 80%, while scraping after one hour and three hours reduced emissions by 78% and 54%, respectively. Pressure washing of farmyards as soon as possible after use by livestock should be encouraged in order to minimise NH_3 emissions from this source.

Ammonia emissions from excreta deposited on pasture

Over 60% of livestock-excreted N is deposited on pasture annually in Ireland. The aim of this task within the project was to create disaggregated NH_3 emission factors for urine and dung applied to pasture, and investigate the effect of amending urine patches with N-stabilised fertiliser formulations over two grazing seasons. Urine and dung were applied with and without a nitrification inhibitor (dicyandiamide) and urease inhibitor (N-(butyl) thiophosphoric triamide) on grassland at Teagasc Johnstown Castle. Dung had a lower NH_3 EF (3.8% total N applied lost as NH_3) compared to urine (12% total N applied lost as NH_3). The N stabiliser formulations applied to urine patches had no significant effect on NH_3 emissions from urine patches.

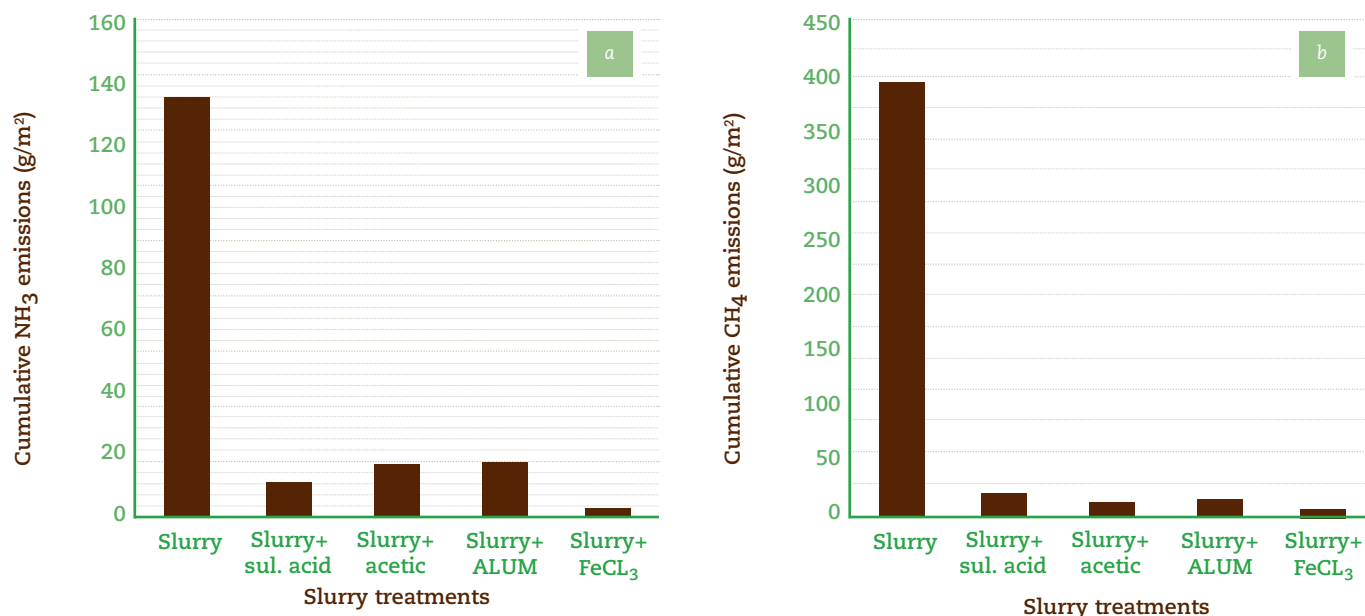


FIGURE 1: Ammonia emissions (a) and methane emissions (b) from stored cattle slurry with and without amendments.

Reducing ammonia and greenhouse gas emissions from slurry storage

Cattle slurry was amended with sulphuric acid, acetic acid, alum, and ferric chloride (FeCl₃) until a target pH of 5.5 was attained. A control, with no amendment, was also included. The study was conducted using 1.6L-capacity containers, which were stored at 8.6°C. Ammonia, N₂O, carbon dioxide and methane emissions from the slurry were monitored for 83 days. The addition of amendments to the slurry reduced NH₃ emissions by 86-97% (Figure 1a). Alum and FeCl₃ produced the highest reductions. The amendments reduced methane emissions by 94-98% relative to the slurry without amendments, with FeCl₃ attaining the highest reductions (Figure 1b). Carbon dioxide emissions were similar across all treatments and N₂O emissions were negligible from both the control and amended slurry.



FIGURE 2: New slurry storage facility at Teagasc Johnstown Castle showing: (a) one of twelve 1m³ concrete storage tanks; (b) dynamic chamber used to measure ammonia and greenhouse gas emissions; and, (c) overview of the facility.

Conclusions and future research

The data collected on the LowAmmo project will feed directly into the refinement of Ireland's national NH₃ inventory. The mitigation options investigated in this project will also provide valuable data for the future development of the NH₃ marginal abatement cost curve (MACC) for Irish agriculture.

The recent development of the new Johnstown Castle slurry storage facility will increase the capacity to investigate the effectiveness of NH₃ and greenhouse gas mitigation strategies across the entire manure management chain. This facility contains twelve 1m³ concrete slurry storage tanks, which have been designed to simulate the storage of liquid slurry indoors in slatted storage tanks (Figure 2).

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Application of wastewater treatment plant sludge to land

FIGURE 1: A field-plot scale study examined the surface runoff of contaminants following the land application of three types of biosolids from the same WWTP.

TEAGASC researchers have been collaborating in a study on the production of sewage sludge from wastewater treatment and its impact on agricultural land in Ireland.

The development of wastewater treatment facilities in Ireland has meant that more wastewater is subject to high levels of treatment. While this is good for the environment, it also means that more sewage sludge – an organic by-product of wastewater treatment – is produced. The production of sewage sludge has increased over the years, and in 2015 more than 58,000 tonnes were produced in the Republic of Ireland. The treatment and disposal of sewage sludge presents a major challenge in wastewater treatment, and although there are many disposal and reuse pathways, in Ireland up to 80% is currently reused on agricultural land. This is done in accordance with current guidance documents and legislation, but there remains concern over the presence of metals, nutrients, pathogens, pharmaceutical and personal care products (PPCPs), and other endocrine-disrupting and synthetic compounds in sewage sludge, which may cause environmental and human health problems. An EPA-funded research project, comprising researchers from NUI Galway, Teagasc and UCD, set out to examine all aspects of sewage sludge production and application to agricultural land.

Aims

The aims of this research were:

1. To quantify the range of concentrations of metals, and of two of the most abundant PPCPs in the world, the antimicrobials triclosan (TCS) and triclocarban (TCC), in treated sewage sludge ('biosolids') from a range of wastewater treatment plants (WWTPs) in the Republic of Ireland.
2. To undertake a field-scale experiment to assess losses of nitrogen (N), phosphorus (P), metals, TCS and TCC, and microbial matter

following successive rainfall events on grassland onto which biosolids had been applied, and to compare the results with another commonly spread organic fertiliser, dairy cattle slurry.

3. To measure the uptake of metals by ryegrass for a period of time after the application of biosolids.
4. To conduct a risk assessment of potential hazards of human health concern based on the experimental data.

To read the published EPA report visit:

<http://www.epa.ie/researchandeducation/research/researchpublications/researchreports/research200.html>

Results

The concentrations of metals in the biosolids in 16 WWTPs examined ranged from 11mg/kg (cadmium) to 1,273mg/kg (zinc), and were within the EU regulatory limits (Healy *et al.*, 2016a). Amounts of two potentially hazardous metals, antimony and tin, for which no legislation currently exists, were much higher than their baseline concentrations in soils, meaning that potentially large amounts of these elements may be applied to the soil without regulation. The antimicrobials, TCS and TCC, neither of which are governed by existing legislation, were present in low quantities, and were well below the concentrations reported elsewhere. Working with colleagues in the Galway-Mayo Institute of Technology, the researchers found that small plastic particles, with particle sizes less than 5mm, called microplastics, were present in the biosolids from all the WWTPs examined (Mahon *et al.*, 2016). As these are potential vectors for the transfer of contaminants, their presence in biosolids is concerning.

Runoff study

A field-plot scale study examined the surface runoff of contaminants following the land application of three types of biosolids (anaerobically digested, lime stabilised, and thermally dried). The biosolids all originated from the same WWTP and, to facilitate comparison to another type of organic waste, were applied at the same rate as dairy cattle slurry to the plots (**Figure 1**). All plots were then subject to numerous simulated rainfall events, during which water flowing over the soil surface ('runoff') was collected and analysed for a range of water quality parameters.

This study found that nutrient concentration in runoff following land application of dairy cattle slurry was far greater than the concentrations arising from the application of biosolids (Peyton *et al.*, 2016). Furthermore, the metals and microbial matter present in the runoff from the biosolids-amended plots were, in general, of the same order as the dairy cattle slurry plots. Therefore, in these respects, the application of biosolids to land did not pose a greater risk than dairy cattle slurry. Furthermore, there was no significant difference in metal bioaccumulation of the ryegrass between plots that received biosolids and those that did not, over the study duration (Healy *et al.*, 2016b).

Exposure assessment models, which considered human exposure to metals and *E. coli* through surface water abstracted for drinking, indicated that the risk of illness was negligible for healthy individuals (Clarke *et al.*, 2016, 2017).

Conclusion

The overall conclusion from this study is that although, in general, land-applied biosolids pose no greater threat to water quality than dairy cattle slurry, and cattle exclusion times from biosolids-amended fields may be overly strict (within the context of current exclusion criteria), a matter of concern is that unlegislated metals, PPCPs and microplastics, found to be present in biosolids originating from a selection of WWTPs examined in this study, may be inadvertently applied to land. With multiple applications over several years, these may build up in the soil and enter the food chain, raising concerns over the continued application of biosolids to land in Ireland.

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References

Clarke, R., Peyton, D.P., Healy, M.G., Fenton, O. and Cummins, E. (2016). 'A quantitative risk assessment for metals in surface water

following the application of biosolids to grassland.' *Science of the Total Environment*, 566-567: 102-112.

Clarke, R., Peyton, D., Healy, M.G., Fenton, O. and Cummins, E. (2017). 'A quantitative microbial risk assessment model for total coliforms and *e. coli* in surface runoff following application of biosolids to grassland.' *Environmental Pollution*, 224: 739-750.

EPA. (2016). 'Urban waste water treatment in 2015.' EPA, Co. Wexford. Available at:

http://www.epa.ie/pubs/reports/water/wastewater/2015%20Urban%20waste%20water%20report_Web%20Version.pdf.

Healy, M.G., Fenton, O., Forrestal, P.J., Danaher, M., Brennan, R.B. and Morrison, L. (2016a). 'Metal concentrations in lime stabilised, thermally dried and anaerobically digested sewage sludges.' *Waste Management*, 48: 404-408.

Healy, M.G., Ryan, P.C., Fenton, O., Peyton, D.P., Wall, D. and Morrison, L. (2016b). 'Bioaccumulation of metals in ryegrass (*Lolium perenne* L.) following the application of lime stabilised, thermally dried and anaerobically digested sewage sludge.' *Ecotoxicology and Environmental Safety*, 130: 303-309.

Mahon, A.M., O'Connell, B., Healy, M.G., O'Connor, I., Officer, R., Nash, R. and Morrison, L. (2017). 'Microplastics in sewage sludge: effects of treatment.' *Environmental Science and Technology*, 51(2): 810-818.

Peyton, D.P., Healy, M.G., Fleming, G.T.A., Grant, J., Wall, D., Morrison, L., Cormican, M. and Fenton, O. (2016). 'Nutrient, metal and microbial loss in surface runoff following treated sludge and dairy cattle slurry application to an Irish grassland soil.' *Science of the Total Environment*, 541: 218-229.

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Municipal organic wastes in crop production

According to **TEAGASC** research, composted municipal wastes have significant potential as a valuable resource for Irish agriculture.

Each year 300,000 tonnes of food in Ireland enters the waste management system. If treated correctly, this material can be utilised as a valuable nutrient resource, as well as protecting soil health. EU Directives stipulate that all member states must divert increasing quantities of untreated organic wastes from landfill, to reduce the production of greenhouse gases caused by the anaerobic breakdown of organic matter. It is stipulated that organic waste should be treated, and composting has been shown to be one of the most cost-effective treatment measures available.

Value of composting

Composting is a process that utilises heat and oxygen to stabilise and reduce organic material to approximately 40-60% of its original volume. As the treatment process is aerobic, carbon dioxide is the primary gas produced, as opposed to methane from organic waste when it decomposes in an anaerobic environment. Quality organic resources such as food waste compost deliver many benefits to soil, in terms of improving soil structure, liming effect and nutrient supply. When composting material, it is usually necessary to add a number of different feedstocks to achieve the optimal carbon:nitrogen (C:N) ratio (30:1) for the quickest and most efficient composting process. Therefore, composts are usually a mixture of a number of different primary feedstocks. A greater understanding of the impact of these primary (initial) feedstocks in heterogeneous composts, on compost quality and nutrient release

from the resultant composts, is required. It is likely that, given current production practices, much of the composted food waste is destined to be spread onto land and, therefore, it is necessary to gain a greater understanding of the nutrient release characteristics of these materials, to increase farmer confidence in substituting inorganic fertiliser with these composted materials. Our study of 25 nationally and internationally sourced composts looked to identify these characteristics as well as identifying additional benefits to applying composts to crop-producing soils, beyond direct fertiliser value.

The role of humic substances

Humic substances (HS) are part of the stable organic matter in composts. During the composting process there is an increase in the accumulation of HS as lignin breaks down and its degradation products combine to form increasingly recalcitrant molecules. Due to the favourable properties of these compounds and their role in C sequestration, they are considered a quality criterion for compost. HS were affected by compost feedstock, with green waste composts generally having the highest mean level of HS (229.6g/kg). Food waste composts (n=12) had slightly lower average levels of HS (194g/kg); also, food waste composts with the highest HS levels were those with a significant green waste content. HS are related to the lignin content ($R^2=0.71$; $p<0.01$), which is highest in green waste and biowaste composts. Manure-

Table 1: Nitrogen uptake results correlated with NDF, lignin and C:N ratio.

	NDF %		Lignin %		C:N ratio	
	R ²	p value	R ²	p value	R ²	p value
Harvest 1	0.81	<0.01	0.74	<0.01	0.17	>0.05
Harvest 2	0.83	<0.01	0.91	<0.01	0.01	>0.05
Harvest 3	0.64	<0.01	0.79	<0.01	0.02	>0.05

based composts had the lowest levels of HS (90.5g/kg) of the composts tested. Generally, the results indicate that where green waste was a component within the initial compost feedstock, HS content was elevated.

Measuring carbon and nitrogen availability

Canadian studies have indicated that applications of 5-10t of compost per hectare per year have been shown to balance the yearly impact of intensive cropping systems, with long-term compost application increasing soil C content.

The C content of food waste composts was found to be high (311.4g/kg); however, it was the quality of that C that impacted on nutrient release from composted wastes. C:N ratio is commonly used as a descriptor of compost quality, but also as a means of predicting N availability. However, this approach was largely developed for organic materials of a homogenous nature, such as spent mushroom compost. As the materials from waste sources are far more heterogeneous, it was found that both neutral detergent fibre (NDF) and lignin content were more accurate in predicting N availability from these materials (Table 1). Overall, the availability of N from composted biowastes is low (approx. 8% of total N in the initial harvest); however, over 24 months, 23% of the total N added in compost form was utilised by plants. When you compare composts made from common municipal wastes, such as catering/food waste and brown bin waste, there was a 19-33% greater uptake of N from pure food/catering waste composts across all harvests, indicating that input feedstock may be affecting release. Even so, commercial growing practices would require the application of an alternative or inorganic N source. Plant growth experiments indicated that once the compost is moderately stable, plant uptake of N from inorganic sources was not affected.

Phosphorus content

Plant uptake and availability of phosphorous (P) from composted wastes from growth experiments was higher than expected, and compared favourably with single super phosphate (SSP). While composted animal manures had the highest availability of P, there were no significant yield differences when biowastes were applied, on the basis of their total P content, to plants whose P fertiliser was applied as SSP at a comparable rate. This finding suggests that

compost application rates should be considered on the basis of their P content.

Conclusions

Composted wastes provide a significant quantity of macro and micro nutrients, while also improving soil structure and soil health. All composted wastes tested over a two-year period displayed a high availability of P and could potentially replace inorganic P to a significant extent. N availability was low and the continued practice of applying composted heterogeneous wastes on the basis of their C:N ratio seems inefficient, particularly where, with composts of heterogeneous feedstock, lignin content or NDF was shown to be optimal in predicting N release. Composted municipal wastes such as food and catering wastes are a valuable resource, which could be utilised more fully in Irish agriculture, helping to sustain intensive cropping systems.

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FIGURE 1: Three 10L laboratory scale continuously stirred tank reactors.

Anaerobic co-digestion of slurry with organic waste

TEAGASC researchers are involved in a study examining the survival of pathogens during anaerobic co-digestion of slurry with a fats, oil and grease substrate.

Background

Manure and slurry from pig, beef, dairy, and poultry enterprises are considered valuable organic fertilisers, but typically contain a broad range of bacterial, viral and parasitic pathogens. These pathogens can be transferred as bioaerosols during landspreading, ingested directly from grass or vegetables, or washed off into surrounding watercourses, posing a significant threat to human and animal health (Bicudo *et al.*, 2003). Some benefits of farm-based anaerobic digestion (AD) include: localised renewable energy production; odour control; organic waste management; and, noxious and greenhouse gas mitigation (Auer *et al.*, 2017). Farm-based AD could also potentially reduce pathogen loads in the environment and their associated public health risks. AD of slurry can reduce pathogen numbers (Sahlström, 2003), but Irish farm-based AD surveys by partners in this project highlighted survival of a number of important pathogens. Pathogen survival may be significantly impacted by factors such as: initial pathogen load; addition of co-digestion substrates such as food production waste; and, operating conditions of AD plants. Congealed fats, oils and grease (FOG) are a major cause of urban drainage maintenance problems; therefore, well-maintained grease traps are mandatory for food service establishments in the EU, providing a ready supply of FOG for co-digestion with animal wastes. Data for pathogen survival during mesophilic AD of cattle slurry mixed with FOG are currently not available. Thus, the aim of this study was to examine the survival of indicator pathogens in AD of slurry with FOG as co-substrate.

Study design

Slurry was obtained from three Irish dairy farms and stored in a shed at ambient temperature. Triplicate 10L continuously stirred tank reactors (CSTRs) were operated under conditions representative of Irish farm-based AD, i.e., 37°C, batch-feeding slurry augmented with FOG, and a 28-day retention time (Figure 1). AD plant performance was assessed by measuring biogas production, pH, chemical oxygen demand, volatile solids (VS) and ammonia concentration throughout the trial. Pathogen survival was assessed by quantifying faecal coliforms, *E. coli* and enterococci over the duration of the experiment.

Initial results

The physicochemical data recorded throughout the trial were analysed to ensure that reactors performed optimally. Temporal changes in pH, ammonia and VS degradation were optimal and were similar for the three reactors. Total chemical oxygen demand (COD) and soluble COD removal and methane generation (mL CH₄/g VS) indicated good performance overall.

All pathogens declined over the duration of the 28-day AD process, generally to below 1,000cfu/g by day seven. Although enterococci numbers were slightly above 1,000cfu/g after 21 days, a 2.5-log₁₀ reduction (below 1,000cfu/g) was observed after 28 days (Figure 2). Total faecal coliforms and *E. coli* survival showed similar trends until day 21, with 4.0 and 3.8-log₁₀ reductions in faecal coliforms and *E. coli*, respectively (Figure 2). By day 28 *E. coli* was no longer detected,

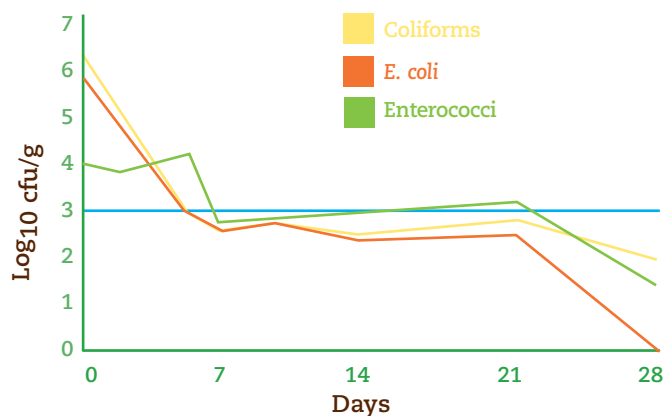


FIGURE 2: Average pathogen indicator survival in 10L reactors (n=3). Blue line indicates 1,000cfu/g threshold.

indicating a 5.9- \log_{10} die-off during that period. The initial 3- \log_{10} reductions of both coliforms and *E. coli* occurring within seven days, followed by relatively stable survival until 21 days, suggests the presence of resilient pathogen strains or cells with increased ability to survive under mesophilic AD conditions. For comparison, levels of pathogen indicators in stored slurry were monitored and much lower pathogen reductions were observed. By day 28 total coliform and *E. coli* levels in stored slurry had declined by 1.4 and 1.8- \log_{10} , respectively, while enterococci levels reduced by 0.67- \log_{10} . After two months of storage, none of the bacterial pathogen indicators in slurry had dropped below 1,000cfu/g, suggesting that slurry would not be considered safe for landspreading if pathogen indicator thresholds required for AD were applied.

Future direction

Significant pathogen indicator die-off was observed but insufficient reduction in enterococci was achieved until day 28. This highlights the opportunity for process optimisation with a focus on pathogen reduction. Other project partners are focusing on survival of protozoa and viral pathogens (UCD) and bacterial pathogens (Teagasc Ashtown) in this experiment. The significant reduction in pathogen numbers in AD compared to stored slurry does however highlight the potential for farm-based AD to decrease pathogen load in the environment and, consequently, to mitigate the risks to human and animal health. Optimisation of operational conditions for pathogen reduction is currently underway. Future work will investigate pathogen survival in soil and potential losses to water from landspreading. Pathogen loss to water will be investigated in runoff trials using simulated rainfall in the field to assess comparative risk from digestate and unprocessed slurry. The combined results of this multidisciplinary research will significantly contribute to Irish AD policy.

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References

- Auer, A., et al. (2017). 'Agricultural anaerobic digestion power plants in Ireland and Germany: policy & practice.' *Journal of the Science of Food and Agriculture*, 97: 719-723.
- Bicudo, J.R. and Goyal S.M. (2003). 'Pathogens and manure management systems: A review.' *Environmental Technology*, 24: 113-115.
- Sahlström, L. (2003). 'A review of survival of pathogenic bacteria in organic waste used in biogas plants.' *Bioresource Technology*, 87: 161-168.

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Potential of recycling dairy processing organic residues



Researchers at **TEAGASC** are examining residues from dairy processing for use as organic fertiliser.

Wastewater created during the production of butter, cheese, milk powders, cream, and whey powders at milk processing facilities must be treated. This results in the generation of dairy processing organic residues (DPOR), which must be managed; approximately 128,636 tonnes were generated in Ireland in 2015. Due to the abolition of European milk quotas in 2015, milk production in the Irish dairy sector is expected to increase by 50% by 2020. This will create an added challenge of tackling more DPOR generation. Recycling of DPOR to land provides for a circular economy and should also provide farmers with an organic fertiliser. However, there is as yet no systematic study of the recycling of DPOR from an Irish perspective in terms of nutrient recovery, agronomic benefit, and associated environmental impacts. Current research in this area within the Teagasc Environment Research Centre is focusing on the recovery and recycling of agri-nutrients (nitrogen (N), phosphorus (P), and potassium (K)) from DPOR. In particular, this project aims to investigate and develop the comprehensive physicochemical characteristics of DPOR from the Irish

dairy processing industry and, subsequently, to identify fertiliser (N/P/K) replacement value and associated agri-environmental impacts from recycling of DPOR through controlled laboratory, micro-plot rainfall simulation and field-scale agronomic trials.

Research method

Seasonal DPOR samples (n=16) (predominantly two types: mixed sludge after biochemical treatment and lime-treated sludge after dissolved air flotation (DAF)) were collected from five dairy processing plants across Ireland. Samples were analysed for physicochemical parameters (e.g., solid and organic matter, nutrients, heavy metals and other elemental composition) following standard sample preparation (homogenisation, freeze drying and grinding in mixer mill). The analytical methods used were inductively coupled plasma optical emission spectrometry (ICP-OES), spectrophotometric measurements by Aquakem 600 discrete analyser, and LECO TruSpec CN analyser.



FIGURE 1: Agronomic grassland plots for assessing nitrogen and phosphorus fertiliser replacement value of dairy processing organic residues through land application.

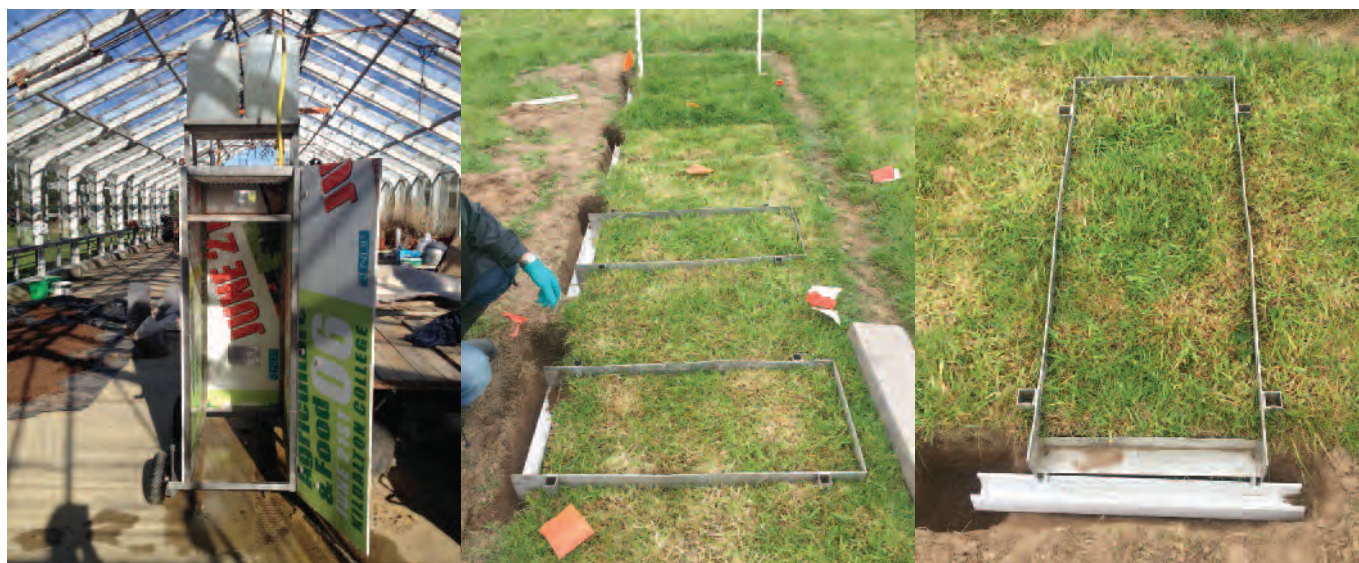


FIGURE 2: Micro-plot rainfall simulation study site. Left: Amsterdam drip-type rainfall simulator. Middle: Series of isolated grassland micro-plots. Right: Individual plot isolated by steel frame of dimension 0.9m in length and 0.4m in width with runoff collection channel.

Results

Preliminary results of the analysis of DPOR samples showed that the values of dry matter (DM, in %wt) and total nutrient content (kg/tonne DM) were in the range of: DM=9.4-19.7, N=37-65, P=18-61, and K=3.5-13.6 for mixed DPOR (n=11); and, DM=19-30, N=9.1-48.7, P=15-82, and K=1.2-6.1 for DAF DPOR (n=5).

The levels of N, P and K in DPOR are generally higher than those typically observed with other commonly used organic fertilisers (e.g., cattle slurry, biosolids), with DPOR also showing lower heavy metal levels (Wall and Plunkett, 2016). Heavy metal levels in DPOR are significantly lower than those regulated by the European Union in agricultural land due to sludge recycling (EC, 2001). An estimated evaluation reflected a higher financial value of DPOR (€13-22/tonne) than cattle slurry (approximately €5.4/tonne) considering total nutrient content. But, it is important to evaluate the realistic fertiliser replacement value (FRV) through agronomic investigation in order to realise the actual commercial value of DPOR. Overall, the results indicate that DPOR are enriched in nutrients. There is significant variation in major nutrient content and other physicochemical composition across different milk processing plants and DPOR types. There are also some indications of seasonal variability in nutrient content and other compositions, which will be statistically analysed when the seasonal sampling is complete.

The next stage

Future work will elucidate the fertiliser (N/P/K) replacement value of DPOR and assess potential agri-environmental impacts through runoff losses, and uptake in soil and grass from the recycling of DPOR to grassland. These experiments have begun in Johnstown Castle with the creation of a new field site (Figures 1 and 2).

References

Wall, D.P. and Plunkett, M. (eds.). (2016). 'Major and micro nutrient advice for productive agricultural crops.' Johnstown Castle, Wexford: Teagasc, Environment Research Centre.

EC. (2001). 'Disposal and recycling routes for sewage sludge.' Part 2 – Regulatory Report, European Commission.

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Herbicide resistance in Irish grass weeds

TEAGASC is looking into herbicide resistance and devising strategies to counteract this serious threat.

Weeds compete with crops for light, water and nutrients, causing reductions in yield, difficulties in harvesting, and in the case of seed crops, rejection of the crop. Grass weeds in particular may be challenging for growers to control due to the fact that cereals are also grasses, limiting options for herbicidal control. Herbicide resistance poses further problems for weed management, increasing costs and eroding profit margin for the grower. Herbicide resistance can be defined as the evolved ability of a plant to survive a dose of herbicide that would normally be lethal. Our research focuses on identifying herbicide resistance in grass weeds on Irish farms and understanding the nature of this resistance.

Approach

Grass weed samples were obtained in 2016 from fields where weed control had been an issue. A library of populations of wild oats (*Avena fatua*), black grass (*Alopecurus myosuroides*), lesser canary grass (*Phalaris minor*) and various species of brome (*Bromus sterilis*, *Bromus diandrus*, *Bromus secalinus*, *Bromus hordeaceus*, *Bromus commutatus*)

was constructed. In all, 77 populations were tested for their susceptibility to four different commonly used herbicide active ingredients. The trial cohort comprised 31 populations of wild oats, 22 populations of brome, 16 populations of black grass and eight populations of lesser canary grass (**Figure 1**). Weeds were treated with pinoxaden, cycloxydim, propaquizafop and meso/iodosulfuron, representing the ACCase- and ALS-inhibiting herbicides (**Table 1**). To determine the levels of resistance present, the biomass of plants sprayed with the various herbicides was compared to that of unsprayed controls (**Figure 2**). Dividing the weight of the biomass of the sprayed plant by the weight of the unsprayed control for a given population allows for a resistance score to be assigned to each population for each active ingredient tested.

Findings

Before making absolute statements about the levels/presence of resistance in Irish grass weeds, more analysis is certainly required. This survey is being carried on in 2017 and 2018. That said, initial findings



FIGURE 1: From left: infestation of wild oats (*Avena fatua*) in spring barley; sterile brome (*Bromus sterilis*) in winter wheat; and, lesser canary grass (*Phalaris minor*) in spring wheat.

Table 1: Overview of weed grass species targeted with this project and identified resistances to available herbicide groups.

Weed species	Resistance found to cycloxydim?	Resistance found to propaquizafop?	Resistance found to pinoxaden?	Resistance found to meso/iodosulfuron?
Wild oats	Yes	Yes	Yes	Suspected
Black grass	Yes	Yes	Yes	Yes
Brome	No	No	N/A; doesn't claim control	Suspected
Lesser canary grass	No	No	No	No

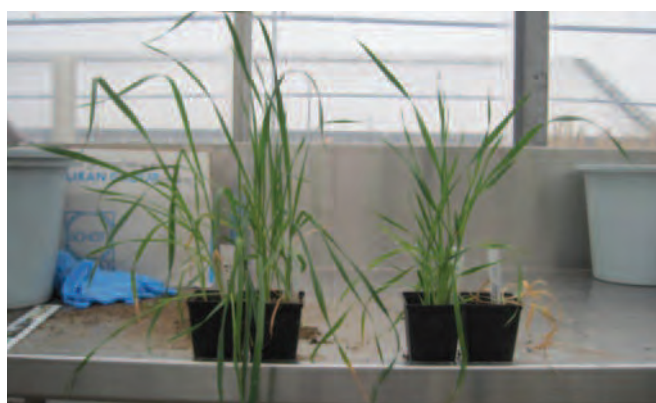


FIGURE 2: Side by side comparison of two pots of unsprayed wild oats (left) and two of sprayed wild oats (right). Note the disparity in size/vigour between the resistant (left) and susceptible (right) plants in the examples on the right. Picture taken three weeks post spraying with cycloxydim.

indicate that 'dim', 'den', 'fop' and sulfonylurea resistance seem to be present in wild oats, with these findings mirrored in tests carried out on black grass. Trials carried out on the various species of brome returned no signs of resistance to ACCase inhibitors, but resistance is suspected to ALS inhibitors (sulfonylureas).

Implications

The implications of these results are profound and add another layer of complexity to a tillage sector that is already under pressure. Studies carried out in Canada and across continental Europe suggest that the spread of herbicide resistance is caused more by the spread of resistant seed, as opposed to independent resistance-endowing mutations. In small geographical areas, such as the Irish grain-producing region, the potential for the spread of resistant genes is significant. Controlling this spread, and furthermore, managing resistant weeds at farm and regional level, may cause input costs to rise and reduce profit margins for growers.

Follow-up studies

The first step following these initial tests is to determine the response of the resistant populations to varying doses of herbicides. This gives a more accurate idea of the levels of resistance at play in these populations, while providing further replication of the experiments to add statistical significance to the data being acquired. Black grass is a relatively new weed in Ireland. While it has been present in extremely low background numbers over the years, the past few seasons have seen an increase in the presence of this

pernicious weed. This in itself is significant, as black grass is one of the most widespread weeds in the UK, with up to 98% of populations showing resistance to at least one herbicide active ingredient. The working hypothesis is that Irish populations of resistant black grass are, in fact, British populations that have migrated to Ireland via imported machinery, seed, bales, etc. Teagasc is carrying out population genetics experiments to uncover the genetic relationship between Irish and British black grass populations.

Further experiments, in conjunction with Rothamsted Research in the UK, aim to investigate the genetic basis for herbicide resistance in Irish grass weeds. This will look at the herbicide target enzymes of the plants, as well as identifying markers for mutations to the cell machinery responsible for detoxifying xenobiotics such as herbicides.

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High pressure processing technology for smoked fish

Researchers at **TEAGASC** have been looking at the combination of high pressure processing (HPP) and smoking to extend the shelf life of mackerel, while also improving its quality attributes.

There is a growing demand among consumers for healthier and safer products with a longer shelf life. Fatty fish species such as mackerel, which have a high nutritional value due to their omega-3 polyunsaturated fatty acids (PUFAs) levels, constitute a valuable food resource in a healthy diet. However, these compounds can be oxidised, with a subsequent deterioration of sensorial quality, and as a consequence, the shelf life of this pelagic fish is shortened. Applying food preservation technologies that inhibit spoilage and increase the shelf life of fresh fish, while maintaining its quality and healthy attributes, is essential for the fish industry. The application of high pressure processing (HPP), a non-thermal and environmentally friendly technology, could satisfy these requirements and help the fish processing industry to meet market demands for longer life healthy products, such as pelagic fish.

HPP technology

HPP technology offers food processors a number of advantages. The energy consumption is low compared with thermal technologies. It is recognised as a minimal processing technology that maintains nutritional value and flavour compounds, as the covalent bonds, associated with an increase of volume, are not disrupted by HPP. According to the principles of HPP, pressure stimulates processes and reactions that are accompanied by a decrease in volume and inhibits those associated with increases in volume. The pressure is applied instantaneously and is uniformly transmitted, independent of the size and geometry of the food, so foods of different volumes can be processed in the same batch. The pressure transfer medium is usually water. The food is packaged and does not directly contact the processing devices, preventing

the secondary contamination of food after pressurisation. This technology eliminates spoilage and pathogenic microorganisms, extending the shelf life and enhancing the microbiological safety of food. For these reasons, the application of HPP is of interest to the seafood industry.

Smoking is a traditional method for food preservation. Smoke penetrates into the food matrix and a partial loss of moisture, often fat, and enzymatic and/or heat-induced modifications of proteins occurs.

HPP can inactivate oxidative endogenous enzymes, involved in lipid and protein oxidation, and so can be used as a pre-treatment before storage and processing of fish products. In addition, it can reduce the contents of biogenic amine compounds (BAs), primarily produced by microbial decarboxylation of amino acids or by enzymes present in raw foodstuffs. In fish, BAs can occur quite commonly due to the fact that post-mortem changes happen very fast. The pressure applied at an industrial level is between 300 and

700MPa and its effect depends on factors such as the pressure intensity, holding time, temperature and food matrix, and also on the type of microorganisms and their physiological state, therefore necessitating optimisation of treatment conditions on an individual commodity basis.

Smoking

Smoking is a traditional method for food preservation. Smoke penetrates into the food matrix and a partial loss of moisture, often fat, and enzymatic and/or heat-induced modifications of proteins occurs. The preparation of the foodstuff, the duration of the treatment, smoke composition, temperature, humidity, handling practices and packaging of the products will determine the effects of the smoking. The smoke components affect the sensory properties of products and have antimicrobial and antioxidant activities. Fish treated with beech tree smoke turn a goldish yellow colour (Figure 1).



Figure 1. Mackerel fillets treated at 500MPa/5 min (left) and treated at 500MPa/5 min combined with smoking (right).

The colour is caused primarily by oxidation and polymerisation of the deposited smoke components, mainly phenols, but is also partially due to the Maillard reaction, with the participation of carbonyl compounds from the smoke and amino groups of the food proteins and amino acids. The aroma of the smoked products comes from the molecules present in the smoke and the substances generated in biochemical and chemical reactions in the food matrix. The typical taste of smoked foods is due to the interaction of phenols, carbonyl compounds, acids and the products of their reactions with the components of the food matrix.

A study carried out by Teagasc has shown that treatments of 300MPa or 500MPa for five minutes could extend the shelf life of mackerel, as a significant reduction of Total Viable Counts (TVC) and H_2S -producing bacteria (below detection limit) was observed in mackerel fillets, immediately after treatments. However, colour changes were detected, with an increase of lightness (L^*) and a decrease of redness (a^*) of mackerel fillets (see Figure 1: left image). These treatments also modified the texture, with an increase of hardness in pressurised samples. In an attempt to introduce desired changes on quality attributes, the pressurisation treatments mentioned above were combined with hot smoking in mild conditions. The mackerel fillets were pressurised and after the

pressurisation treatment, they were brined (200g/L NaCl) for three minutes, sprayed with tap water, dried at 15°C for one hour, heated at 47°C for 1.5 hours and smoked at 45°C for 1.5 hours. A considerable improvement in colour characteristics was achieved when HPP was combined with smoking (Figure 1) along with textural properties.



Conclusions

The combination of HPP and smoking has been demonstrated to enhance the quality attributes of mackerel, contributing to the maintenance of its nutritional value, and is a promising treatment to extend the shelf life of mackerel.

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Utilising every drop of milk

Research at **TEAGASC** is looking at ways to add value to milk co-products.

All milk constituents are not created equal. This is reflected in the milk pricing system used by most Irish co-ops, where price is calculated on levels of protein and fat. Lactose and minerals contribute more than 40% of the milk solids but do not factor in the pricing system. From an economic perspective this reflects the relatively low added value of carbohydrate- and mineral-rich dairy streams.

With global food demand expected to grow by up to 70% over the next 30 years, it is becoming increasingly important for dairy processors to utilise every last drop of milk. In particular, growing volumes of low-protein co-products from the manufacture of protein concentrates will be a challenge for the industry.

Traditionally, these streams were considered waste or by-products; however, co-product is a term that is increasingly applied. This reflects a shift in mentality and a recognition that as supply of and demand for milk grows, it is increasingly important to obtain as much nutritional and economic value from milk as possible. One does not need to look too far from home for an example of transformation of a waste stream into value-added co-product. Until the late 20th century, whey was considered a necessary nuisance in the manufacture of many cheeses and was largely disposed of as untreated waste. However, increased understanding of the environmental and economic impact of dumping a large proportion of milk solids, in combination with advances in nutritional science and process technology, has transformed whey and its derivatives into a mature market of significant importance to the Irish economy. This article explores how recognition that low-protein and low-fat dairy streams are underutilised, along with technological advances, could turn the by-product of today into the co-product of tomorrow

Background

Increasing production of high-protein dairy ingredients and consumer products, in combination with an expanding dairy market, is resulting in a growing pool of high-lactose streams for valorisation. These streams are generally made through the physical separation of milk proteins from lactose and minerals, usually by means of membrane filtration or coagulation of protein. They are classified into three main groups: milk permeate from standardisation of milk; whey permeate from manufacture of whey protein concentrate; and, acid whey from manufacture of Greek-style yogurt, quark, etc. (despite the name, acid whey contains little whey protein).

High-lactose dairy co-products can be used as the starting material for lactose production, where lactose is crystallised from a solution and separated from the mother liquor by mechanical means before drying. Lactose powder has many applications in the food industry; in particular, lactose is widely used in the infant formula industry as a pure source of lactose, as it contains far less minerals than permeates, etc. Often dairy co-products are dried as is to produce permeate and/or acid whey powders. Permeate powders have applications in baking and confectionery production, and as a low-cost replacement for whey, lactose or other dairy powders. The market for permeate powders could increase in the coming years with the publication of a CODEX standard, which is currently under preparation. A CODEX standard is often seen as a precursor for regulatory approval of products outside of the EU, and has sparked interest in the potential of selling co-product powders into the Chinese market.

As volumes of high-lactose streams increase, dairy processors will face challenges. This is particularly true in the Irish context, where drying is essential for valorisation of dairy streams. Processors may be faced with scenarios where drying of large pools of permeate-type streams reduces

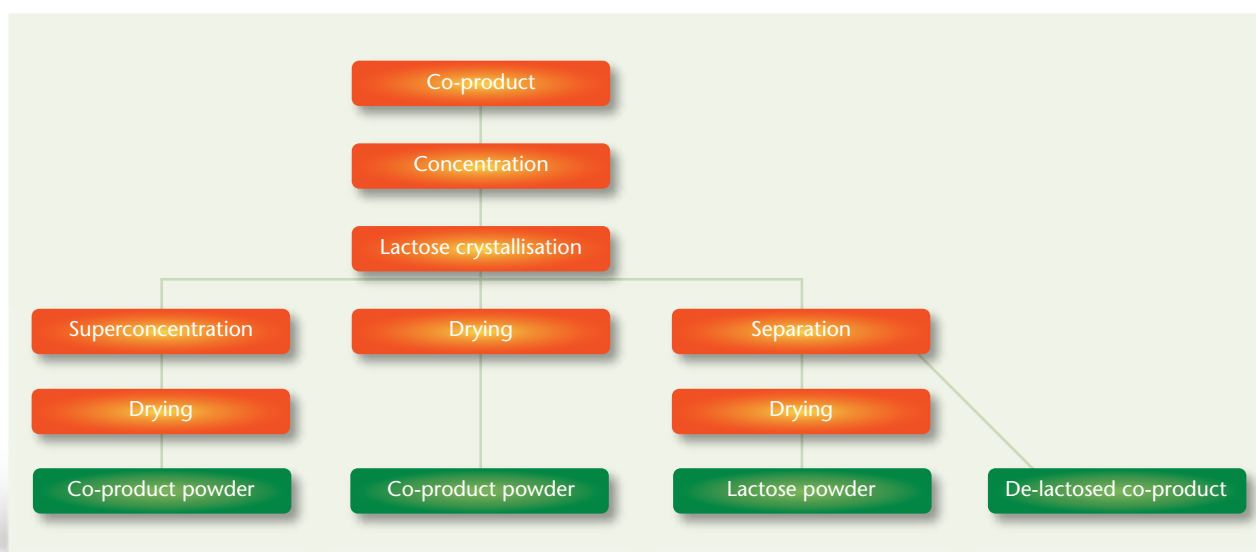


FIGURE 1: Dairy co-products can be processed using a few different methods.

the capacity available for the drying of higher-value ingredients. As a consequence, processors may be faced with a choice between disposing of permeate in liquid form or investing in increased drying capacity. Applied research is required to tackle the challenge of growing permeate pools by increasing the efficiency of current drying processes and investigating lower-cost alternatives.

Crystal clear – increasing process efficiency

There are a number of routes for processing high-lactose co-products (Figure 1). In Ireland, the most common processing routes are direct drying of the co-product, or separation and subsequent drying of lactose from the intact stream. A common element in both routes is lactose crystallisation, and the process control during this operation is central to process efficiency.

Direct drying of high-lactose co-product streams (at lactose levels equivalent to >80% of dry solids) presents a technological challenge due to the sticky nature of lactose in its amorphous form. It is necessary to transform amorphous lactose in these streams to non-sticky crystalline lactose prior to spray drying. Inefficient crystallisation not only leads to problems with drying but can also cause storage instability in the finished product. Likewise, in the case of lactose manufacture, lactose crystal separation from the mother liquor is governed by the extent and size of crystals produced. Work is currently underway at Teagasc to characterise the conditions at which crystallisation can be optimised in order to add value to co-product and lactose streams through better process efficiency and product quality. However, while optimisation of current processes is important, it is essential to recognise that alternative processing and valorisation routes will be required in future to obtain the most value from growing co-product volumes.

Future proofing

Standard practice for manufacturing co-product powders is to evaporate the dilute stream to approximately 60% total solids, crystallise and dry. Many processors use existing energy-intensive, spray drying plants designed for the drying of conventional, proteinaceous dairy powders (skim milk, protein concentrates). Novel processes are being developed in which the initial concentration is maximised to produce super-concentrates, which can then be dried using more cost-effective compact driers. In one case, a super-concentration process has

been designed which removes the need for a spray-drying tower altogether. In addition to energy reduction, such processes could provide processors with a lower-cost supplementary drying technology, which liberates existing spray-drying capacity for the manufacture of high-value dairy ingredients. However, work is still required to test process robustness on the commercial scale.

Teagasc project 0185, 'Valorisation of Dairy Co-Product Powders through Optimisation of Concentration and Drying Technologies', will commence in October 2017. The project will focus on improving efficiency of current processes and investigate new technologies for the manufacture of high-lactose dairy co-products. The project will be carried out in conjunction with INRA-Agrocampus Ouest, France.

References

- Tanguy, G., et al. (2017). 'Efficient process for the production of permeate powders'. *Innovative Food Science & Emerging Technologies*, 41: 144-149.
- Astley, M. (2015). 'Permeate market will 'explode into life' once Codex standard set: Arla Food Ingredients'. *Dairy Reporter*. Available at: <http://www.dairyreporter.com/Ingredients/Permeate-market-will-explode-into-life-once-Codex-standard-set-Arla-Foods-Ingredients> [Accessed May 9, 2017].
- Smithers, G.W. (2008). 'Whey and whey proteins—from "gutter-to-gold"'. *International Dairy Journal*, 18: 695-704.
- Keller, A.K. (2007). 'Process for drying high-lactose aqueous fluids'. U.S. Patent No. 7,241,465, July 10, 2007.

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Patterns of meat consumption in Ireland

TEAGASC researchers are looking at meat consumption patterns to see what they tell us about Irish consumers.



Food choice

An understanding of drivers of food consumption and behaviour patterns can enhance marketplace effectiveness for many food companies. A thorough understanding of the factors underpinning current meat consumption patterns can provide valuable information to the meat industry for effective targeting of consumers with new product offerings.

Meat segments

The aim of this research, which was completed in conjunction with University College Cork, was to determine if distinct meat consumption patterns are evident among Irish consumers. These segments were profiled based on demographic characteristics and food choice attitudes. Segmentation is commonly used in market research to identify distinct consumer groups or segments based on similar characteristics. In addition to traditional segmentation variables, such as age, gender and geographic location, segments can also be derived based on attitudes, behaviours or preferences. Using National Adult Nutrition Survey (NANS) data, reported meat consumption for beef, pork, poultry and lamb was subjected to cluster analysis to identify meat consumer segments displaying similar behavioural patterns. Six distinct segments of meat consumers were identified (Table 1) and named based on the consumption patterns that best differentiated between the segments. These segments were then profiled based on socio-demographic characteristics, attitudes and dietary behaviours.

'Processed pork indulgers' comprised 13% of respondents, and derived the highest proportion of their energy intake (28%) from meat in their diet. They had fat intakes above what is recommended for a healthy diet. The meat products most consumed were pork

based, with this segment consuming five times more sausages/bacon/pudding than the other segments. This segment was characterised by a high proportion of men from a lower socioeconomic background, who had little motivation to eat healthily. 'All things meat', the smallest segment at 4%, consumed all meat types but had the highest lamb consumption of all segments. Energy from meat was 26% and fat intakes were slightly above what is recommended for a healthy diet. Membership of this gender-balanced segment was associated with being older and rural dwelling. 'Chicken eaters' comprised 20% of respondents, had the highest chicken meat consumption of all segments, and derived 22% of their energy intake from meat. They were more likely to be younger, physically active and urban dwellers. They displayed lower motivation to eat healthily than many other segments but were motivated by weight control and taste.

Representing 21% of the population each, 'fish eaters' and 'beef focused' both derived 19% of their energy intake from meat. The fish eaters segment consumed nearly twice as much fish as beef, chicken and pork. Fish eaters were associated with being older, female, and strongly motivated to eat healthily. The beef-focused cluster consumed the most beef and had a relatively low consumption of other meats. The gender-balanced beef-focused segment had total fat intakes in line with healthy guidelines. Meat provided 14% of energy intake for 'diverse moderates', who also accounted for 21% of the population. Their consumption of all meats was at a moderate to low level.

Opportunities

The fish eaters segment was the most motivated to eat healthily. They have heard the message about the health benefits of fish

Table 1: Meat consumption and dietary characteristics of Irish meat consumers.

	Processed pork indulgers	All things meat	Chicken eaters	Fish eaters	Beef focused	Diverse moderates
Cluster size (%)	13	4	20	21	21	21
Age (years)	45	56	38	50	43	45
Body mass index	28	28	27	27	27	26
Energy from meat (%)	28	26	22	19	19	14
Energy from fat (%)	37	36	34	35	34	34
Fat from meat (%)	37	38	28	26	25	19
Beef (g/day)	88	41	43	33	124	30
Chicken (g/day)	49	38	138	35	39	46
Fish (g/day)	8	36	15	79	20	11
Pork (g/day)	108	24	28	37	30	39
Lamb (g/day)	6	66	2	4	1	17
Turkey (g/day)	3	9	1	2	1	4
Game, offal (g/day)	1	22	0	1	0	2

consumption, but this does not include meat consumption for them. Promotion of the benefits of lean meat may appeal to this group. The young chicken-consuming urbanites ranked taste and eating enjoyment as more important to them than health and nutrition. To this cluster with a lower body mass index, weight control when selecting foods was of greater importance than it was to others. They have heard the message that chicken can be incorporated into a lean diet, but that has not limited their selection of chicken type, with consumption of processed and food service chicken high. This contributed to the high proportion of their energy gained from meat compared to the beef-focused segment. A more rounded awareness of the nutritional profile of all meats would benefit these young consumers of chicken. Other meat product offerings that are low calorie and convenient may appeal to this group. Price-sensitive male indulgers ate the most sausages/pudding/rashers. Convenience was no more or less important to them than to other segments and health was of low relevance. These mostly-overweight males appear relatively unconcerned about the health consequences of their food choices.

From a public health perspective, there is a need to decrease this segment's fat intake levels but this is not going to present as an attractive market opportunity. To attract this segment's attention away from high fat, alternative leaner meats should be presented as offering strong enjoyment and taste benefits, thus taking a somewhat stealth approach to health.

This research has shown how meat plays a diverse role in the diets of Irish adults and is influenced by a range of food choice motivations. These motivations can be used for effectively targeting new meat products to the intended consumer segment.

Acknowledgements

This research was funded by the Department of Agriculture, Food and the Marine through the FIRM programme (ReVisData (13/F/527)). The authors thank Janette Walton and the Irish Universities Nutrition Alliance (IUNA) for access to the National Adult Nutritional survey data used in this research. For more information, see www.iuna.net.

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More than just milk!

Researchers at **TEAGASC** and University College Cork have profiled dairy consumption patterns in Ireland with the aim of identifying market segments for new product development.

Knowledge on consumer attitudes and motivations that underpin dairy consumption behaviour can be powerful in informing new product development strategies and in ensuring appropriate targeting of consumers. An extensive analysis of dairy consumption patterns has been undertaken by researchers in Teagasc, Ashtown and UCC for the purpose of providing a detailed profile of Irish adult dairy consumers. Using data from the National Adult Nutrition Survey of 1,500 Irish adults, dairy food intake from nine categories of products was subjected to cluster analysis to identify dairy consumers' segments. These segments were then profiled based on socio demographic information, attitudes and dietary behaviours.

Seven distinct groups of dairy consumers, with varying dairy consumption patterns, were identified and profiled (see **Table 1** for summary information). Each segment was named to reflect the feature that differentiated it most from the other segments. The 'dairy fuellers' accounted for 9% of the population and consumed the most dairy of all segments. In fact, 20% of their total dietary energy came from dairy foods. They consumed over 500g of dairy per day and the biggest contributor was full-fat milk, consuming practically no low-fat milk and only small amounts of cheese and yogurt. They had the second highest fat intake at 37% and the lowest body mass index (BMI) of all the groups. Members of this group were more likely to be men and physically active.

The second segment was named 'dairy lovers' as they were partial to a little bit of all the dairy foods. At 9% of the population, dairy accounted for 15% of all of the energy they consumed. They were predominantly low-fat milk consumers, with moderate cheese

consumption and high yogurt consumption. They had the second lowest fat intake at 32% and had the highest BMI. Members of this group were more likely to be older rural-dwelling women. Representing 12%, 14% and 11% of the population, respectively, were the 'daily yogurts', 'cheese please' and 'added benefits' segments – all of these segments derived a similar proportion of energy from dairy at around 12%, albeit from different dairy groups. The daily yogurts segment, as the name suggests, consumed more yogurt than the other segments. They had low milk consumption but were more likely to choose low-fat milk if doing so. This group included a greater proportion of women who displayed a high level of motivation for healthy eating. Cheese please, as the name also suggests, had the highest cheese consumption, with low consumption of milk and yogurt. Members of this group were younger and displayed a moderate level of motivation towards healthy eating. All those in the added benefits cluster consumed fortified low-fat milk and were more inclined than other segments to consume yogurts with functional claims. Although there was an even split of men and women in this group, the women were older and motivated by healthy eating.

The two remaining segments, 'conservatives' (23%) and 'dairy dabblers' (22%), accounted for almost half of the population. Conservatives had low consumption of cheese and yogurt and almost all the dairy consumed was full-fat milk. They derived less than 10% of their energy from dairy and had the second highest overall fat intake, with a BMI comparable to many of the other clusters. They were more likely to be men and had low levels of motivation in

Table 1: Clusters of dairy consumption segments and their dietary characteristics for 1,500 Irish adults.

	Dairy fuellers	Dairy lovers	Daily yogurts	Cheese please	Added benefits	Conservatives	Dairy dabblers
Cluster size (%)	9	9	12	14	11	23	22
Age (years)	44	47	47	41	48	44	43
Body mass index	26	28	27	27	27	27	27
Energy derived from dairy (%)	20	15	13	13	12	9	5
Energy derived from fat (%)	37	32	34	37	32	36	34
Fat derived from dairy (%)	27	17	16	21	13	13	7
Full-fat milk (g/day)	467	6	49	64	10	170	11
Low-fat milk (g/day)	2	352	53	43	13	20	70
Fortified low-fat milk (g/day)	0	4	9	3	236	1	2
Cheddar cheese (g/day)	10	7	7	29	5	5	2
Other cheese (g/day)	4	7	7	11	6	2	2
Yogurt (g/day)	18	30	70	9	17	7	6
Functional yogurt (g/day)	16	23	38	4	20	7	7

relation to healthy eating. Dairy dabblers were so named due to their low consumption levels across all dairy groups. They derived only 5% of their total energy intake from dairy foods and were more likely to be younger, with a moderate level of interest in healthy eating.

Dairy opportunities

Knowing what distinguishes one type of dairy consumer from another provides evidence-based insights that can be used to develop strategies to more effectively reach target markets. For dairy fuellers, where milk in particular plays such a significant part in their diet, there is potential for increased consumption of cheese, by promoting its high protein content. However, this needs to be achieved without an increase in the already high fat intakes in this group.

For the cheese please segment, where foods 'on-the-go' have appeal, dairy products designed to offer convenient healthy foods may have appeal as they can leverage on an attenuated interest in health by minimising effort in planning and preparing healthy options. The added benefits segment members are confirmed functional food consumers. They are looking for more than the intrinsic health benefits of dairy and are receptive to dairy products that are fortified and functional. For these strongly health-motivated older women, who have received and heard the health benefit message regarding fortified milk, tailored products in the yogurt and cheese categories, with benefits that are relevant to their life stage, should be of interest to them. The males choosing fortified dairy were more likely to be moderately motivated to eat healthily, so they may view fortified dairy as a convenient way to eat healthily. Dairy needs to continue to appeal to the health motivation of this group.

However, the fact remains that nearly half of the population (45%) consumes low amounts of dairy, with the conservatives consuming only milk, with little or no cheese and yogurt, and the dabblers consuming very little across all of the dairy categories. The health aspect of dairy foods is not a motivation for consumption in these groups. Convenience may appeal to the conservatives, while novel uses may appeal to the dabblers.

These findings confirm that 'one-size-fits-all' is not the case when it comes to dairy consumption patterns in the Irish population. Equally, consumers' motivations are diverse and the dairy solutions chosen to satisfy these motivations are wide ranging.

Acknowledgements

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The authors thank Janette Walton and Irish Universities Nutrition Alliance (IUNA) for access to the National Adult Nutrition Survey data used in this research. For more information see: www.iuna.net.

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Brace for Brexit

What is the potential impact of a 'hard' Brexit on Irish farm level income and economic viability?

Introduction

While there are a lot of unknowns at this stage in relation to the Brexit process, it is safe to say that the outcome will affect a wide range of issues, including the movement of goods (trade), people and capital. Given the significance of Irish agri-food exports to the UK, it is not surprising that the Brexit vote has caused significant debate and uncertainty within the Irish agri-food sector.

While there has been some diversification away from the UK market over the past decade, it still accounted for 37% of Irish food and drink exports, valued at €4.13bn, in 2016 (Bord Bia, 2017). Although much uncertainty remains as regards the longer-term impact of Brexit on Irish-UK agri-food trade, slower growth and weaker farm gate prices in Ireland can be expected to result from Brexit. The Irish beef and dairy sectors are particularly vulnerable, with half of all beef exports (in both value and volume terms), and one-third of the value of all dairy exports, going to the UK in 2016.

Against this background, the objective of recent research carried out by economists in the Department of Agricultural Economics and Farm Surveys in Teagasc, was to carry out a farm level impact assessment

for Irish farms, with a focus on the possible impacts on farm income and economic viability.

What assumptions were made in the analysis?

The farm level impact assessment used micro data from the Teagasc National Farm Survey (NFS). A set of informed assumptions regarding the potential impacts of a 'hard' Brexit outcome on the future level of farm prices and support payments was assembled following a literature review (primarily based on van Berkum *et al.*, 2016) and stakeholder consultation. The analysis is static in that no account is taken of the impact on levels of agricultural activity of the reduced levels of profitability likely to result from Brexit.

Implications for farm income

Baseline data from the Teagasc NFS were used to determine the potential impact of the assumed price and income support reductions that might result from Brexit for the main sectors of Irish agriculture: dairy; beef; sheep; and, tillage. Price reductions are sector specific and reflect the relative dependence on the UK market of the different

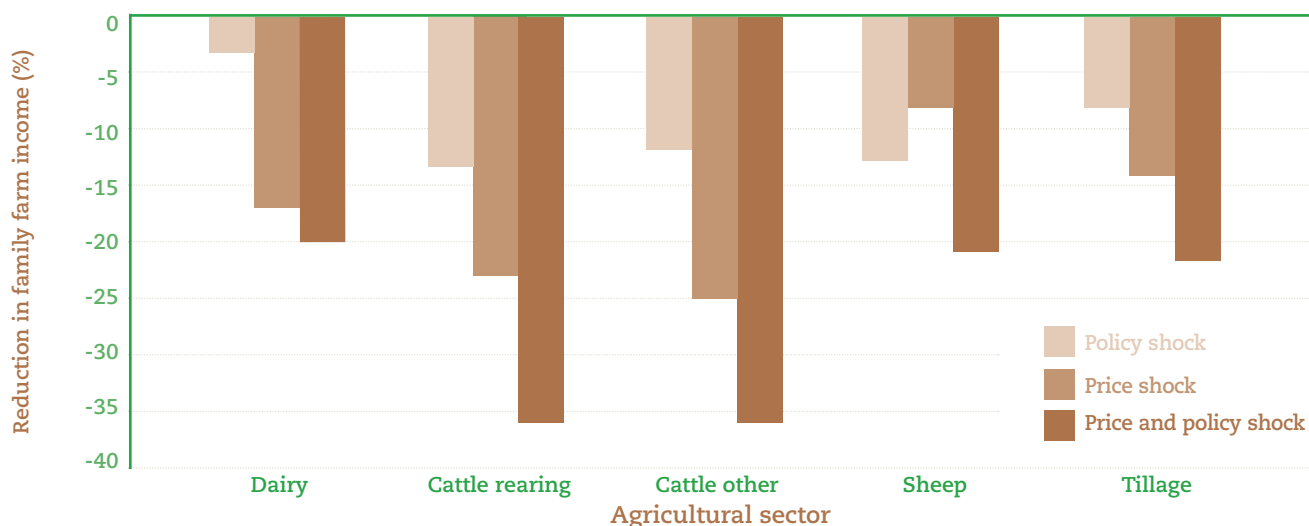


FIGURE 1: Potential impact of a hard Brexit on family farm income, by system.

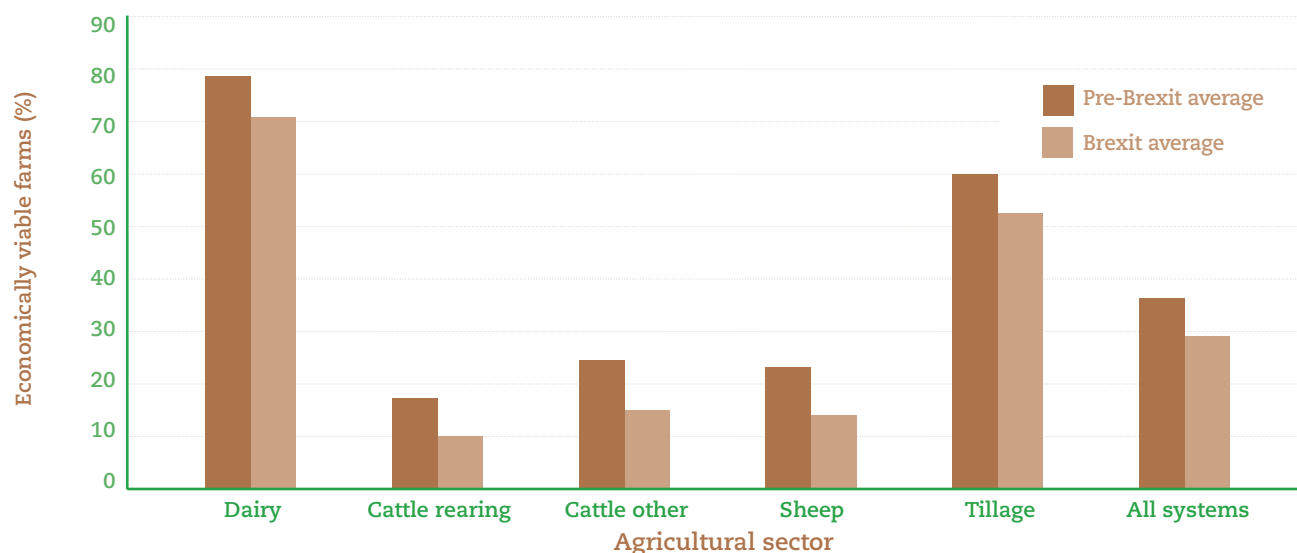


FIGURE 2: Potential impact of a hard Brexit on proportion of economically-viable farms, by system.

sectors, and the potential impact on prices of Brexit under an assumed trade liberalisation scenario (van Berkum *et al.*, 2016).

In addition to the market price impact of Brexit, a 10% reduction in Common Agricultural Policy (CAP) support across sectors was assumed to result from Brexit, due to the reduction in the EU CAP budget that will follow the exit of the UK from the EU. The UK is currently the second largest net contributor to the EU budget (Matthews, 2016).

Figure 1 shows that the two cattle systems in the Teagasc NFS were the most exposed to both the price and policy shocks applied. This is a result of their high exposure to the UK market and their reliance on direct payments. Given an assumed 10% beef price reduction from Brexit, coupled with a 10% reduction in the Single Farm Payment, family farm income (FFI) on the average Irish cattle farm would drop by more than one-third. The presence of a cattle enterprise on dairy farms, alongside an assumed reduction in the Irish milk price of 5%, resulted in a projected decline in dairy farm incomes of 20%. Similarly, FFI on sheep farms was projected to decline by 21%, even though a decline of only 5% in prices was assumed. The decline in incomes on Irish sheep farms was also driven by a high dependence on subsidies and the importance of beef output as a secondary enterprise on many sheep farms. For similar reasons, FFI on tillage farms was projected to decline by 22% (given the beef component of output), although cereal markets are least likely to be affected by Brexit (with an only -1% price shock assumed) among the four farm types examined.

Implications for economic viability

The implications of the Brexit-related FFI reductions, as outlined in **Figure 1**, for the economic viability of Irish farming were examined using the Frawley and Commins (1996) definition of economic viability. Frawley and Commins defined a viable farm as one having: (a) the capacity to remunerate family labour at the minimum agricultural wage; and, (b) the capability to give an additional 5% return on non-land assets.

Figure 2 shows that economic viability levels fell by over 20% in the 'hard' Brexit scenario analysed, with the cattle and sheep sectors the worst affected, due to a combination of price and decoupled income support payment reductions.

Conclusions

The farm level analysis carried out has shown that the effects of the assumed price and direct payment support changes have very

different impacts across the sub-sectors of Irish agriculture. The Irish beef sector is likely to suffer the largest negative impact in terms of farm income and of economic viability.

Further reading

Donnellan, T., Hanrahan, K. and Thorne, F. (2016). 'Brexit Update: Considering the Impact on Irish Farm Incomes.' Available at: https://www.teagasc.ie/media/website/publications/2016/BrexitNov_R_and_O_final_for_web.pdf.

van Berkum, S., Jongeneel, R.A., Vrolijk, H.C.J., van Leeuwen, M.G.A. and Jager, J.H. (2016). 'Implications of a UK exit from the EU for British agriculture.' Available at: https://www.wur.nl/upload_mm/b/1/3/5f8e5eb2-305a-4a06-9e48-627f9f448c96_2016-046%20Berkum_DEF.pdf.

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Competitiveness of Irish agriculture

TEAGASC economists review a decade of competitiveness on Irish farms.

How do farms in Ireland compare with farms in other countries, in terms of output price, costs of production and profit margin? With the abolition of the milk quota system and the ambitious plans for the Irish dairy and other agriculture sectors set out in the 'Food Wise 2025' report (the Irish Government's strategic plan for the development of the agri-food sector over the next decade), the competitive position of Irish agriculture and the determinants of this competitiveness performance will be critical in framing public policy that seeks to maximise the contribution of the agri-food sector to the Irish economy. Hence, the objective of recent research published by Teagasc was to measure the competitiveness of Irish agriculture for the major agricultural commodities of relevance to Ireland.

Competitive performance within the EU

Costs as a percentage of output are considered as an indicator of competitive performance, namely profitability, because both costs and returns are considered. Using this indicator as a measure of competitive performance, **Figure 1** shows that the competitive position for Ireland within the EU for the four enterprises examined – milk, beef, cereals and sheep – was positive when cash costs were measured as a percentage of total output (including an allocation of decoupled payments). Irish dairy and cereal producers also had lower cash costs as a percentage of market-based output, relative to the average of all countries examined. However, Irish 'specialist beef', and 'specialist sheep' farms had 13% and 7% higher cost/output ratios, respectively, compared to the average of all the EU countries studied, when market-based output was considered. As the opportunity cost of owned resources is not included in this calculation, this indicator of competitiveness can only be considered to be valid in the short term. In the longer term, relative owned-resource costs are needed to understand the likely future adjustment pressures.

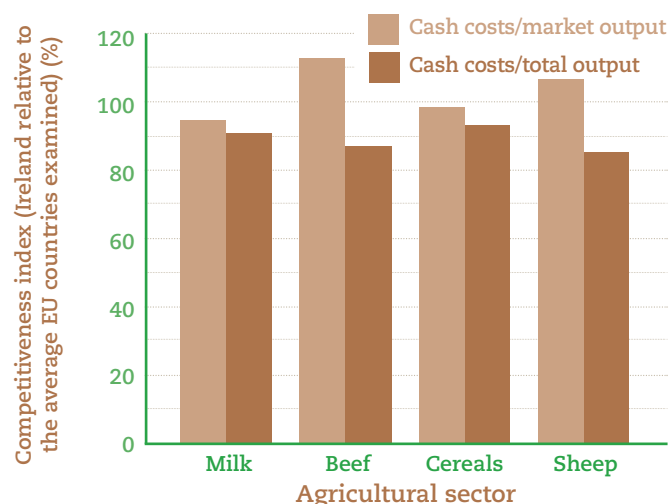


FIGURE 1: Cash costs as a percentage of market-based output and total output for Irish farms by sector (2009-2013) compared with the rest of the EU.

When imputed costs for owned resources are considered, the competitive ranking for Irish agriculture slipped relative to the average for the other EU countries. **Figure 2** shows that on a total economic cost basis, Irish cereal and dairy producers were the only categories of farms where costs as a percentage of total output approached the average of all countries examined within the EU. On an economic cost basis, Irish beef farms and sheep farms appeared to be uncompetitive relative to the average of the EU countries studied, when costs were expressed as a percentage of market-based output. As relative economic costs are considered as a guide to the longer-term competitive position of competing countries, these findings should be considered as warning signals for the future competitive performance of Irish beef and sheep production.

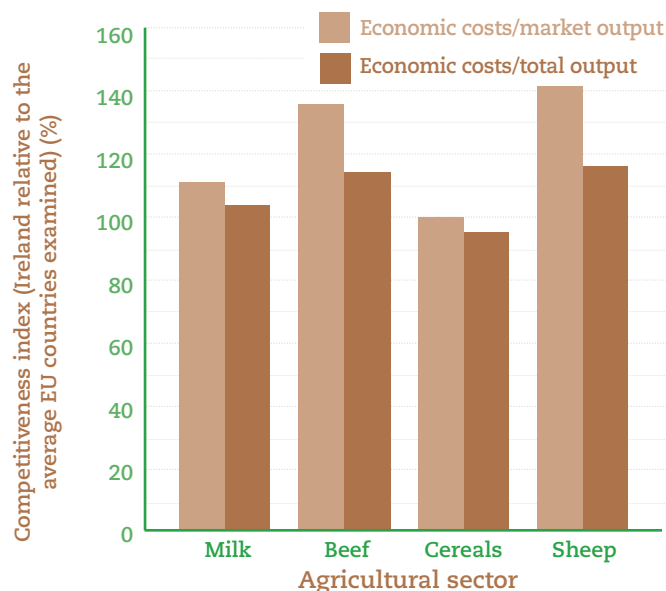


FIGURE 2: Economic costs as a percentage of enterprise output for Irish farms by sector (2009-2013) compared with the rest of the EU.

Competitive performance outside of the EU

The results from this study show that the competitive position of Irish dairy farms compared with countries outside the EU was very positive when cash costs were considered in isolation from imputed charges for owned resources. Furthermore, based on data from the International Farm Comparison Network (IFCN) for dairy, the larger-sized Irish dairy farm (which would be representative of typical larger Irish dairy farms) had the lowest cash cost to output ratio when compared to the key international milk-producing regions examined, namely, the USA, New Zealand and Australia.

When economic costs are considered, the competitive ranking for the Irish dairy sector, for the average-sized farm in particular, slipped relative to the other countries examined. However, the ability of the larger Irish dairy farms to compete in the longer term in a global context was affirmed. Furthermore, as Irish dairy farming transforms to larger scale production in the post-quota environment, the Irish milk sector's competitive position will be strengthened and thus will be better able to cope with a future cost/price squeeze.

Finally, in relation to the competitive performance for Irish beef farms outside the EU, the results of this study were not very positive, even when only cash costs of production were considered. Based on data from the international agri benchmark network for beef, representative Irish beef finishing and cow-calf farms were in the top quarter of representative farms on a cash cost per kg of carcass/liveweight basis. For both finishing and cow-calf farms, Irish farmers had lower cash costs than some North American and Canadian cow-calf farms; however, the total returns from these North American farms in general were superior to those on the typical Irish farm.

When economic costs were considered, the competitive ranking of the Irish beef sector, for the average size farm in particular, slipped further relative to the other countries examined. This highlights the

international competitiveness challenge faced by typically-sized Irish cow-calf and beef finishing farms.

Implications for the sector

The results of this study provide a baseline position against which the change in competitiveness of Irish agriculture can be measured. This is an important development in the process of monitoring the position of Irish agriculture relative to other EU and non-EU countries. As evolving topics such as trade liberalisation in the context of Brexit negotiations and reform of the Common Agricultural Policy (CAP) will all have major influences on the competitive position of Irish agriculture, the new methods and suite of indicators developed as part of this project will provide a timely and routine metric of the multi-faceted definition of competitiveness, which can be monitored in the future.

Acknowledgements

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Further reading

Thorne, F., Gillespie, P.R., Donnellan, T., Hanrahan, K., Kinsella, A. and Läßle, D. (2017). 'The Competitiveness of Irish Agriculture: A Decade in Review.' ISBN 978-1-84170-634-4. Available at: <https://www.teagasc.ie/media/website/publications/2017/The-Competitiveness-of-Irish-Agriculture.pdf>.

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June

June 21, 11am-5pm *Teagasc Animal and Grassland, Research and Innovation Centre, Athenry*

TEAGASC SHEEP OPEN DAY

An opportunity for flock owners to review the latest research and technical advice from Teagasc and its practical application for their home farms. Among the highlights will be the results from the sheep research demonstration farm in Athenry. There will be a major emphasis on grass-based systems of lamb production, breeding incorporating the indices, economic evaluations, genomic selection, and looking at low and high index rams, flock health and hill sheep production.

www.teagasc.ie/news--events/news/2017/sheep-open-day-.php
Contact: michael.diskin@teagasc.ie

June 28, 11am-5pm *Teagasc Crops, Environment and Land Use Research Centre, Carlow*

CROPS AND CULTIVATIONS – OAK PARK OPEN DAY

An opportunity to view and discuss the crop research experiments at Oak Park, as well as machinery stands and live cultivation demonstrations. Teagasc researchers and tillage specialists and advisers will display the latest research findings for a wide range of tillage crops, including winter and spring barley, oats and beans, and winter wheat and oilseed rape. The open day is free to attend, and all tillage farmers and those involved in the sector are welcome.

www.teagasc.ie/news--events/news/2017/crops-and-cultivation-day.php
Contact: eleanor.butler@teagasc.ie

JULY

July 4, 10am *Teagasc Moorepark, Fermoy, Co Cork*

NATIONAL DAIRY OPEN DAY TEAGASC MOOREPARK 2017

The theme of this year's event is 'Resilient Technologies'. Moorepark '17 is an ideal opportunity to see at first hand the results of the comprehensive research programme at Moorepark, and to meet Teagasc research, advisory and education staff. Industry experts will be present to discuss individual farmer queries. All dairy farmers and dairy industry stakeholders are welcome.

www.teagasc.ie/news--events/national-events/events/national-dairy-open-day.php
Contact: margie.egan@teagasc.ie



July 17-21 *University College Dublin*

36TH INTERNATIONAL SOCIETY OF ANIMAL GENETICS CONFERENCE

An open and friendly forum for the sharing of knowledge between scientists and practitioners of animal genetics applied to economically important and domesticated species. The conference will include: plenary sessions with invited presentations from the world's leading scientists; workshop sessions; poster presentations; and, social functions.

www.isag.us/2017 **Contacts:** sinead.waters@teagasc.ie,
donagh.berry@teagasc.ie

AUGUST

August 10-11 *Teagasc Food Research Centre, Ashtown, Dublin 15*

UNECE MEAT QUALITY WORKSHOP

The Government of Ireland, in collaboration with Teagasc, will host a United Nations Economic Commission for Europe (UNECE) workshop

focusing on eating quality, beef and lamb carcass grading to underpin consumer satisfaction, and the implementation of UNECE standards. The workshop will also be supported by Meat Standards Australia.

www.icomst2017.com/unece-meat-quality-workshop/

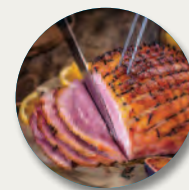
Contact: Liliana.Annovazzi-Jakab@unece.org; Tel: +41 (0) 22 917 1176

August 13-18 *Rochestown Park Hotel, Cork*

ICOMST – 63RD INTERNATIONAL CONGRESS OF MEAT SCIENCE AND TECHNOLOGY

The theme of the Congress is 'nurturing locally, growing globally': exploring how science can offer the meat production and processing sector solutions to enable it to nurture sustainably at local level while offering opportunities to grow globally. The Congress will end with a discussion on the role of meat in the diet.

www.icomst2017.com Contact: icomst2017@teagasc.ie

**SEPTEMBER**

September 4-6 *Clayton Whites Hotel, Wexford, Ireland*

17TH INTERNATIONAL RAMIRAN CONFERENCE

RAMIRAN, 'Recycling of Agricultural, Municipal and Industrial Residues in Agriculture Network', is a research and expertise network dealing with environmental issues relating to the use of livestock manure and other organic residues in agriculture. The overall theme is 'Sustainable utilisation of manures and residue resources in agriculture', which will be examined under the sub-themes: advances in technologies; crop nutrition; gaseous emissions; soil and water quality; and, adoption and impact.

www.ramiran2017.com Contact: ramiran2017@abbey.ie



September 7, 2pm *Keadeen Hotel, Newbridge, Co Kildare*

NATIONAL CROPS FORUM

Organised by Teagasc tillage specialists, the Forum will look at the new varieties available this year and also at economic returns from the Teagasc e-Profit Monitor. There will also be a focus on issues around Brexit, the developing agricultural policy in both the UK and Europe, and the potential effects of changes on the tillage industry in Ireland.

www.teagasc.ie Contact: michael.hennessy@teagasc.ie

September 25-26 *Teagasc Ashtown, Dublin*

XXXI EURAGRI CONFERENCE

This conference will address the different dimensions of research management in the context of an evolving European research agenda, focusing on the functions and challenges of research organisations concerning organisational and strategic management, including planning and implementation.

www.teagasc.ie/news--events/euragri-conference/
Contact: eilish.cray@teagasc.ie

For a full list of Teagasc food industry training events see:
www.teagasc.ie/food/food-industry-development

For presentations from previous Teagasc events see:
www.teagasc.ie/publications