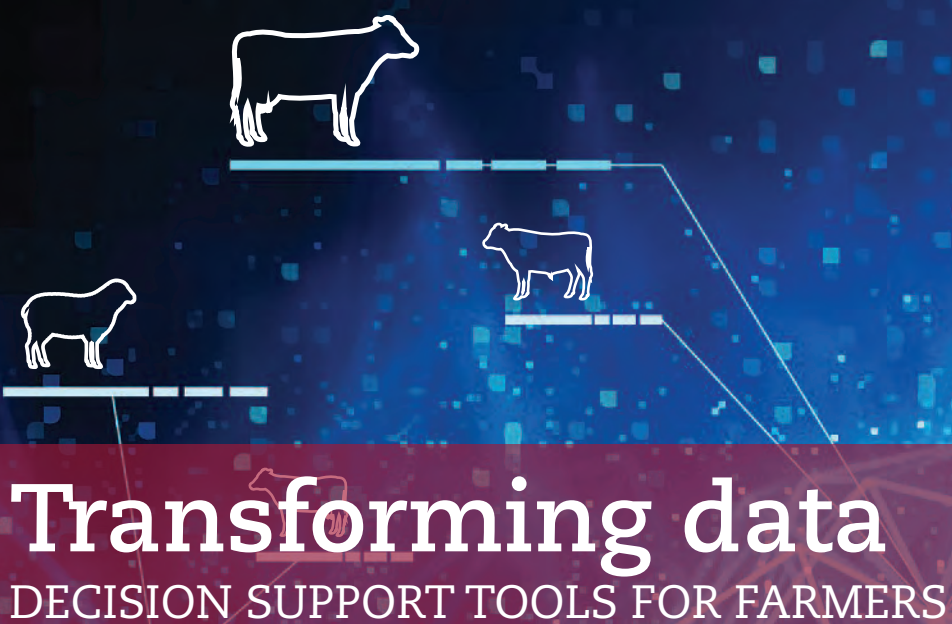


# Research

Volume 13: Number 1. Spring 2018



## Transforming data

DECISION SUPPORT TOOLS FOR FARMERS

GLOBAL COLLABORATION  
SPORES IN DAIRY PROCESSES  
AGRISPIN

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## Why scientists should engage with the public

In 2015, Science Foundation Ireland (SFI) commissioned a study carried out by Millward Brown entitled *Science in Ireland Barometer*, which analysed the Irish public's perceptions and awareness of STEM (science, technology, engineering and maths) in society. In summary, the study found that while half of the Irish population feel uninformed about STEM, 58% are interested in it. However, according to SFI, this positive feeling is tempered by a lack of confidence in and connection to the role of science in people's lives; 71% of Irish adults feel developments in science and technology are too specialised to understand (this compares to 35% in New Zealand). Not only that, but nine out of 10 surveyed agreed that young people's interest in STEM is essential for our future prosperity.

Teagasc has long been involved in science outreach activities such as Science Week, aimed mainly at secondary school and third-level students. In recent years, we have stepped up our involvement with the BT Young Scientist and Technology Exhibition and we have expanded the audiences of our Science Week events to include primary level students and open 'edutainment' events for the general public. Many of our researchers also participate in public engagement events such as FameLab, 'I'm a Scientist, Get me out of here', and so on.

This year, Teagasc's Research Directorate is establishing a Science Communications and Outreach Working Group. This Working Group will enable Teagasc to take a more co-ordinated approach to science communication and outreach activities across Teagasc's research programmes. Through this we hope to communicate the relevance of our science to the everyday world, and there is no shortage of material across our research programmes, from the health of our soils to clean watercourses, and from developing sustainable methods of animal production to food safety and the development of new food products.

It is important for Teagasc to communicate the relevance of its work to everyday lives and to the development of Irish society and the economy (particularly the agri-food sector) to stimulate interest, excitement and debate about STEM. An engaged and scientifically informed society benefits society as a whole.



**Catriona Boyle**

Science Communications and Outreach,  
Teagasc Head Office

## Cén fáth ar cheart d'eolaithe caidreamh a dhéanamh leis an bpobal

Sa bhliain 2015, choimisiúnaigh Fondúireacht Eolaíochta Éireann Millward Brown chun staidéar dar teideal *Science in Ireland Barometer* a dhéanamh. Rinneadh anailís sa staidéar sin ar dhearccháí phobal na hÉireann i leith STEM (eolaíocht, teicneolaíocht, innealtóireacht agus matamaitic) sa tsochaí agus ar an bhfeasacht atá aige air. Mar achoimre, fuarthas amach sa staidéar go bhfuil spéis ag 58% de phobal na hÉireann in STEM, cé go measann leath an phobail gur beag eolas atá aige air. Dar le Fondúireacht Eolaíochta Éireann, áfach, baintear den mhothúchán dearfach atá ag daoine i leith STEM mar gheall ar an easpa muiníne atá acu san ábhar agus ar an easpa tuisceana atá acu ar an ról a imríonn an eolaíocht i saol daoine; measann 71% d'aoisigh in Éirinn gurb amhlaidh, mar thoradh ar a speisialaithe atá siad, go bhfuil sé róchasta dóibh forbairtí san eolaíocht agus sa teicneolaíocht a thuiscint (i gcomparáid le 35% d'aoisigh sa Nua-Shéalainn). Ní hamháin sin, ach chomhaontaigh naonúr as gach deichniúr a ndearnadh suirbhé orthu go mbeadh ár rathúnas amach anseo ag brath go mór ar spéis a bheith ag daoine óga in STEM. Le fada an lá, tá Teagasc ag glacadh páirt i ngníomhaíochtaí for-rochtana eolaíochta amhail Seachtain na hEolaíochta, atá dírithe go príomha ar dhaltaí meánscoile agus ar mhic léinn tríú leibhéal. Le blianta beaga anuas, tá ról méadaithe glactha againn i dTaispeántas Eolaí Óig agus Teicneolaíochta BT agus tá an líon rannpháirtithe inár Seachtain Eolaíochta méadaithe againn trí ról a thabhairt do dhaltai bunscoile inti agus trí imeachtaí oscailte oideachais shiamsúil a reáchtáil don phobal i gcoitinne. Chomh maith leis sin, glacann cuid mhór dár dtaighdeoirí páirt in imeachtaí rannpháirtíochta poiblí amhail FameLab, 'I'm a Scientist, Get me out of here' agus araile.

Tá Grúpa Oibre um Chumarsáid agus For-Rochtain Eolaíochta á bhunú ag Stiúrtóireacht Taighde Teagasc i mbliana. Cumasóidh an Grúpa Oibre sin do Teagasc cur chuige níos comhordaithe a ghlacadh i leith gníomhaíochtaí Cumarsáide agus For-Rochtain Eolaíochta ar fud a Chlár Taighde. Tá súil againn a ábhartha atá an eolaíocht don ghnáthshaol a léiriú tríd an obair sin. Tá cuid mhór ábhar ann ar fud ár gclár taighde, lena n-áirítear sláinte ár n-ithreacha, cúrsaí glanuisce, forbairt modhanna inbhuanaithe táirgthe ainmhithe, sábháilteacht bhia, agus forbairt táirgí nua bia.

Tá sé tábhachtach go léireoidh Teagasc a ábhartha atá a chuid oibre don ghnáthshaol agus do shochaí agus geilleagar na hÉireann (go háirithe an earnáil agraibhia) a fhorbairt chun spéis agus dúspéis in STEM a spreagadh agus díospóireacht faoi STEM a chothú. Is chun tairbhe don tsochaí ar fad atá sochaí a bhfuil spéis aici san eolaíocht agus a bhfuil eolas aici uirthi.

**Catriona Boyle**

Cumarsáid agus For-Rochtain Eolaíochta  
Ceannoifig Teagasc

## BTYSTE 2018

Over 20 Teagasc staff and students volunteered to present at the Teagasc stand at the 2018 BT Young Scientist and Technology Exhibition, which is the longest standing display of secondary school students' abilities in the area of science and technology.

The Teagasc special award at BTYSTE 2018 was presented to Darragh Twomey, Neil O'Leary and Andrew Heffernan, transition year students at Colaiste Treasa, Kanturk, Co. Cork, for their project entitled 'Feeding 9.6 billion people by 2050 – the effects of *Pseudomonas fluorescens* L321 endophyte on enhancing barley crop yield'.

The students were runners-up in the group section, which is a great achievement considering 4,251 students from 383 schools entered 2,031 projects for BTYSTE 2018. John Spink (Head of the Crops Research Department at Teagasc Oak Park) assisted the boys throughout their project.



Pictured at the Teagasc stand at BTYSTE 2018 are (from left): Karl Richards, Tomás Byrne, Karen Daly, Susanne Barth, Catriona Boyle, Michael Gaffney, Sara Vero and Grainne McMahon.

## Future Research Leaders

Teagasc and the European Commission will co-fund a new programme which will employ 20 new experienced researchers for 36 months each over the next five years. The fellowships aim to develop the next generation of agri-food research leaders to underpin the objectives of Ireland's Food Wise 2025 strategy. This new programme, which launches in Spring 2018, offers applicants the opportunity to conduct their research in the best academic, or non-academic, organisation of their choice worldwide (outside of Ireland) for 18 months, followed by a return phase to Teagasc (Ireland) for a further 18 months. The programme will have a total value of €5.2 million and will have two funding calls, each funding 10 fellowships. There will be a strong focus on the career development of the researchers, with all fellows undertaking an accredited management course, having a dedicated career mentor (separate to their scientific supervisors) and attending an annual retreat with presentations from established research leaders in industry, academia and civil society organisations. This programme will

also address the 'leaky pipeline' whereby many promising female researchers do not achieve senior positions. An international expert advisory board will review all documentation for the programme to ensure that there is no unintended bias. Remote review cohorts and the final review panel will be gender balanced. A dedicated section of the website will highlight positive reasons for female researchers to apply for the fellowship. Successful female applicants will be facilitated in finding a senior female researcher to serve as a career mentor. Speaking about the new programme, Teagasc Director of Research Frank O'Mara said: "Teagasc is very excited to announce this programme and looks forward to applications from excellent researchers who will work in the best research environments worldwide and then bring that experience and expertise back to Teagasc. This represents a major investment for Teagasc in the future and the next generation of leaders in agri-food research and innovation". Full details can be found at [www.teagasc.ie/rl2025](http://www.teagasc.ie/rl2025)

## Unravelling the cattle genome

A paper entitled 'Meta-analysis of genome-wide association studies for the stature of cattle reveals numerous common genes that regulate size in mammals', which is co-authored by Teagasc quantitative geneticists Deirdre Purfield and Donagh Berry, has just been published by *Nature Genetics*.

The study was the result of a collaboration between 31 academic institutes and industry partners from 13 different countries. The analyses undertaken by the Teagasc geneticists were based on over 5,000 dairy animals and over 20,000 beef animals. Results from the combined analyses revealed that the genetic architecture of stature in cattle is influenced by a very large number of DNA variants and is more similar to that in humans than it is to dogs.

An article on this research will be published in the Summer 2018 edition of *TResearch*.



Teagasc geneticists Donagh Berry and Deirdre Purfield have been analysing the cattle genome for genes that regulate size.

## Better water with science

Teagasc Agricultural Catchments Programme



AVERAGE GROUNDWATER NITRATE LEVELS WELL BELOW WORLD HEALTH ORGANISATION STANDARD

**6** CATCHMENT AREAS | **300** FARMERS | **ONE** TEAM | **NANDP** EFFICIENCY IMPROVING | **TEAGASC** ADVISORS ARE KEY INFLUENCERS

## Invention of the Year awards

Congratulations to Debebe Alemayehu (formerly Teagasc) and Mary Rea of Teagasc Food Research Centre, Moorepark who, with UCC co-inventors Paul Ross and Colin Hill, recently won the Teagasc Invention of the Year award. This event was hosted by UCC as part of the Bridge Network Consortium annual commercialisation awards, which comprise the Technology Transfer Offices (TTOs) of Teagasc, UCC, Cork IT and IT Tralee. The winning invention, selected by an external panel, was submitted to Teagasc TTO in 2016 for assessment, and relates to a novel *Lactobacillus gasseri* strain and its use for treatment of *Clostridium difficile* infections.

A second Teagasc invention was also acknowledged at the awards, having been shortlisted as a finalist, involving Catherine Stanton and Paul Simpson of Teagasc, Moorepark, with UCC co-inventors Paul Ross and Gerald Fitzgerald. This involved novel fermented skimmed milk powders with bifidogenic activity, with potential as prebiotic ingredients. Also present were Teagasc TTO staff members Miriam Walsh and Sharon Sheahan, who were case managers involved in assessing the shortlisted inventions.



Pictured at the Invention of the Year awards are (from left): Sharon Sheahan, Teagasc; Anita Maguire, UCC; Michael Lucey, Purdy Lucey; Mary Rea, Teagasc; Debebe Alemayehu, formerly Teagasc; and, Miriam Walsh, Teagasc.

## Health and safety among dairy workers

An eBook on 'International Perspectives on Health and Safety among Dairy Workers: Challenges, Solutions and the Future' has been published in the open access journal *Frontiers in Public Health, Occupational Health and Safety*.

Teagasc's Health and Safety Specialist, John McNamara, contributed

a paper on 'The Roles of Financial Threat, Social Support, Work Stress, and Mental Distress in Dairy Farmers' Expectations of Injury'. The eBook is based on 11 papers by 32 authors on health and safety topics in dairying internationally, and can be found at <http://bit.ly/HandSDairy>.

## FameLab

Three Teagasc Walsh Fellow PhD students recently participated in the Cork heats of FameLab Ireland. Ciara O'Donovan is an Alimentary Pharmabiotic Centre-funded Walsh Fellow in the Food Biosciences Department at Teagasc Moorepark. Her talk was on the impact of travel on the gut bacteria of the Irish cricket team. Caitlin Looney is a Teagasc Walsh Fellow in the Grassland

Department at Teagasc Moorepark and her talk was on agriculture in the Burren and how it shapes the landscape. Aoife McHugh is a FIRM-funded Teagasc Walsh Fellow in the Food Biosciences Department at Teagasc Moorepark. Her talk was on the survival of spore-forming bacteria in the processing of dairy to a powder.



The science outreach FameLab event at Triskel Arts Centre, featuring (above, from left) Teagasc's Aoife McHugh, Ciara O'Donovan and Caitlin Looney.

## Researcher profile

## Brijesh Tiwari



Brijesh Tiwari is a Principal Research Officer at Teagasc Food Research Centre, Ashtown, Dublin 15.

Brijesh completed a BSc(Hons) in Agriculture and Animal Husbandry at Govind Ballabh University of Agriculture and Technology, Pantnagar, India, and an MSc (Food Technology) at the Central Food Technological Research Institute, Mysore, India.

He then travelled to Ireland to undertake a PhD in Biosystems Engineering at University College Dublin, which he completed in 2009. He commenced work as a Senior Research Officer in Teagasc Ashtown in 2013, after numerous university lecturing and research positions in the UK and India, and became a Principal Research Officer in Teagasc in February 2017. Brijesh's primary research interests relate to novel food processing, extraction and preservation technologies, with a strong focus on investigation of biochemical and microbial reaction rates in food and food products. He has developed, funded and led *ab initio* his Advanced Food Processing

Technologies Research Group to become a strong multidisciplinary research group with an excellent track record in delivering high-quality research and innovation metrics, including patent and technology transfer. Food safety and improving shelf life have been focal points of Brijesh's career. His work has looked at new ways of preserving meat and other food products, and improving food safety. One of the projects he worked on with Teagasc was Waste2Fuels, which examined the potential of generating biofuels from waste by-products. His research is strongly aligned with key national and EU programmes such as Horizon 2020. Brijesh's research group

has a strong focus on societal and economic impact and he is eager to see his research transfer into practical applications in industry. He has served as editor and on the editorial boards of many publications relating to his field of research including: *Journal of Food Processing and Preservation*; *Ultrasonic Sonochemistry*; *Food Engineering Reviews*; and, *Innovative Food Science and Emerging Technologies*. Brijesh's was born in Varanasi, India and is the youngest in his family, with one brother and one sister. His father (now retired) was a professor of plant pathology in India and Brijesh followed him into a career in science.



## APC public engagement award



Ciara O'Donovan was recently awarded the 2017 Alimentary Pharmabiotic Centre (APC) public engagement award. Ciara (pictured above, fourth from left) is an APC-funded Walsh Fellow PhD student in the Food Biosciences Department in Teagasc, Moorepark. Her research involves exploring the compositional and functional profiles of the gut microbiome of athlete groups, as well as the impact of travel on the gut microbiome in athletes. Ciara said: "This year I was both shocked and delighted to receive the 2017 APC public engagement award. During 2017 I was involved in a number of education and outreach activities including primary school visits in Watergrasshill, Banteer, Dromagh and Ballydesmond, the 'Science for All' competition, which I competed in the finals of, a talk to transition year students as part of the 'Budding Biologists' programme, an *Evening Echo* article outlining my research to the general public, helping with the organisation of a student symposium which was hosted in both the APC and Teagasc, winning the food zone in the 'I'm a Scientist' competition, and helping out at stands at a number of events including the Higher Options exhibition, Mallow Maths and Science Festival, celebrate science family day, and a sports, nutrition and the microbiome evening in Páirc Uí Chaoimh. I have always had a great interest in getting involved in a variety of outreach activities and am so lucky to have supervisors who encourage engagement in these events. To receive acknowledgement for something I already enjoy doing is just an added bonus. I have thoroughly enjoyed all of the activities I have participated in during the year and I really feel they have helped me to learn how to present my research to a variety of different audiences".

## EIP funding success

The Department of Agriculture, Food and the Marine held a competitive call to fund European Innovation Partnership (EIP) Operational Groups (OGs) under the Second Pillar of CAP in 2017. Results of this call were recently announced and of the 12 OGs funded, Teagasc leads one and is a partner in a further eight. Michael Hennessy, Head of the Teagasc Crops Knowledge Transfer Department, will co-ordinate 'Wider Adoption of Sustainable Conservation Tillage Systems'. OGs are multi-partner groups with complementary expertise that come together to solve a specific problem or create a specific innovation. They are action-focused groups and target a result that will be implemented by end users (usually farmers who are also members of the OG).

## Research captured in a winning image

The winning image of CommBeBiz's 2018 Photo Competition, entitled 'It's what's inside that counts', depicts the potential of the human microbiome to fight antimicrobial resistance. Photographed by Kevin Egan of the Alimentary Pharmabiotic Centre and based at University College Cork, with colleagues working on the Peptide Protectants project, the photo shows a bacteriocin (nisin) producing colonies of *Lactococcus lactis* inhibiting vancomycin-resistant enterococci (VRE), an important nosocomial (hospital-acquired) superbug.

Kevin said: "This photo highlights the potential of the human microbiome as a source of novel antimicrobials, which can be used to fight the oncoming antimicrobial resistance (AMR) crisis. Supporting and funding microbiome/antimicrobial research in the future will play a key role in improving public health outcomes and decreasing the potential economic burden that AMR presents".

The annual competition was organised by the EU-funded CommBeBiz project (of which Teagasc is a partner) to demonstrate to researchers that strong images can help to communicate the relevance and impact of their bioeconomy research. Stephen Byrne, Crops Science Department, Teagasc, Oak Park was one of the two runners up with his image 'The Breeding of the Perfect Crisp'. Stephen said: "It is important to communicate the essential role plant breeding can play in responding to societal challenges and in the European bioeconomy, and the photo competition was a great opportunity to promote my EU-funded research in this area".

The top six photos chosen by the three judges can be viewed on the CommBeBiz website at <http://bit.ly/CommBeBiz> and two more Teagasc images feature in this shortlist. The competition was run in conjunction with the Teagasc Research Images Competition.

Right: It's what's inside that counts.

Below: Breeding for the perfect crisp.



# Farmers' health for sustainable farming

Research into farming characteristics and farmer health could contribute to the design of strategies to improve farmer health and well-being.

Sustainable farming includes possibly interrelated economic, environmental and social dimensions. Within the social dimension, farmers' health and well-being is a major component. This article presents the findings of a study of Irish farmers related to farming characteristics and self-reported health outcomes. It provides pointers to areas where improvements in farmers' health can be encouraged. It is recognised that there is a high incidence of occupational injury and disease among farmers. Irish farmers, however, also represent a high-risk group for lifestyle diseases. Research has found that Irish farmers had significantly higher mortality rates from cardiovascular disease (CVD), cancers and any cause of death compared to other occupational groups. The factors underpinning the health inequalities of Irish farmers are not fully understood. This study sought to address this gap by examining the relationship between male farmers' self-reported health outcomes and health behaviours on the one hand, and their age and farming characteristics on the other.

## Measuring farming and health

Ethical approval for this research was granted by the Ethics Committee of Waterford Institute of Technology. This cross-sectional study used self-reported quantitative data gained from male farmers ( $n=316$ ) over 18 years of age from the south-east of Ireland, who attended either a Teagasc training course or Irish Farmers' Association (IFA) and Irish Rural Link meetings. From the target group, 314 farmers (99%) filled in the questionnaire, which was modelled on the SLÁN 2007 survey. Data analysis included chi-square analysis to explore associations between farming characteristics and self-reported health outcomes. The significant outcomes were then subjected to binary regression to analyse what farming characteristics predict the likelihood (odds ratio  $>1$  increased/ $<1$  decreased likelihood) of reported health outcomes (Table 1).

## Doctor visits and health indicators

Farmer participants were from a range of ages:  $<45$  years (59%), 45-64 (35%), and  $\geq 65$  (6%); from full time (68%) and part-time (32%) farming; and, from different farm enterprises – cattle/suckler (31%),

dairy and drystock (27%) and other (42%). Over half of farmers (57%) reported having visited a doctor in the past 12 months, which is somewhat lower than the national average for Irish males (65%). One in five farmers (20%) reported never having consulted a doctor. Over one-third of farmers (39%) reported having experienced ill health in the past 12 months, mainly lower back pain, arthritis (rheumatoid and/or osteoarthritis) and/or anxiety. One in five farmers (20%) reported being a current smoker, compared to the national average of 24% for Irish males. The majority of farmers (88%) reported regular consumption of alcohol, with 22% reporting weekly drinking, which is considerably lower than the 60% national average for Irish males. One in five farmers (22%) also reported weekly 'binge' drinking ( $\geq 6$  standard alcoholic drinks per drinking session), which is similar to the national average of 21%. Significant binary regression (Table 1) findings showed that 'younger' farmers ( $<45$  years) were more likely to report smoking and weekly alcohol consumption. Farmers  $>45$  years were more likely to report having arthritis. Full-time farmers were more likely to report having lower back pain in the past 12 months.

## Putting health first

Older farmers ( $>45$  years) were significantly more likely to report having arthritis, with the proportion of those reporting rheumatoid arthritis (13%) being three times higher than the national average of Irish males. It is well known that arthritis has a detrimental effect on job productivity, and therefore might impact negatively on farm productivity and farm income. Although farmers over 45 years of age were significantly more likely to report having used doctor services in the past 12 months, and engagement in preventive health check, overall reported use of doctor services was lower compared to the national average of Irish males. 'Working identity' tends to be highly important for farmers and work might be put ahead of any other responsibilities in life, such as health. 'Younger' farmers ( $<45$  years) were more likely to report harmful health behaviours such as smoking and 'binge' drinking. The negative health effects of smoking are well established. Binge drinking has been found to be an independent risk factor for ischaemic stroke.



**Table 1: Socio-demographic and farming characteristics impacting farmers' self-reported health – binary analysis.**

Independent variable	Dependent variable	P value*	Odds ratio**	95% confidence interval for odds ratio***	
				Lower	Upper
	<b>Health rating very good – excellent</b>				
Age in years <45 ≥45 (indicator)		<b>0.046</b>	1.738	1.010	0.992
Farm enterprise Mixed (indicator) Dairy Cattle		<b>0.013</b> 0.863	2.129 1.062	1.177 0.534	3.851 2.115
	<b>Utilisation of doctor services in past 12 months</b>				
Age in years <45 (indicator) ≥45		<b>0.001</b>	2.553	1.482	4.398
	<b>Engagement in health screening in past 12 months</b>				
Age in years <45 (indicator) ≥45		<b>0.001</b>	3.078	1.746	5.426
	<b>Lower back pain</b>				
Full-time farming Part-time (indicator)		<b>0.029</b>	2.449	1.093	5.484
	<b>Arthritis</b>				
Age in years <45 (indicator) ≥45		<b>0.001</b>	6.312	2.139	18.627
	<b>Smoking</b>				
Age in years <45 ≥45 (indicator)		<b>0.001</b>	4.252	1.931	9.363
	<b>Alcohol</b>				
Age in years <45 ≥45 (indicator)		<b>0.020</b>	2.73	1.173	6.355

\*P: findings are statistically significant from reference value.

\*\*OR (odds ratio): measurement of association between an exposure and an outcome.

\*\*\*CI (confidence intervals for odds ratio): range of observed effect.

### Insight into farmer health

This study acknowledges the limitations of convenience sampling and the 'healthy worker' effect. Self-report measures rely on participants providing honest and reliable responses and should, therefore, be treated with caution. Despite these limitations, this study offers useful insights into the association between farming characteristics and self-reported health outcomes. The findings identified self-reported patterns of precarious health behaviours among subgroups of Irish farmers for whom targeted health interventions are warranted.

### Further reading

This article is based on the recently published paper: Van Doorn, D., Richardson, N., Storey, A., Osborne, A., Cunningham, C., Blake, C., *et al.* (2018). 'Farming characteristics and self-reported health outcomes of Irish farmers'. *Occupational Medicine*, kqy020. Available from: <https://doi-org.ucd.idm.oclc.org/10.1093/occmed/kqy020>.

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# Global knowledge

TEAGASC is part of a strategic collaboration with AgResearch New Zealand, INIA Uruguay, and IRTA Spain focused on improving grassland agriculture.



In 2015, Teagasc signed a partnership agreement with AgResearch in New Zealand, INIA (Instituto Nacional de Investigación Agropecuaria) in Uruguay, and IRTA (Institut de Recerca i Tecnologia Agroalimentaries) in Spain to promote increased collaboration on research in grassland agriculture. The agreement became operational in 2017.

The partnership focuses on exploring the sustainability and competitiveness challenges facing the grassland sectors (dairy, beef and sheep) in each of the participating countries, while protecting and maintaining the environment and delivering added value to consumers. Given that this is a global focus, each of the participating organisations will identify key niches where it can provide innovative solutions and transition pathways to address the challenges, while acknowledging the social, economic and cultural context within which each organisation operates.

The objective of the partnership is to work together to address common issues in the grassland sector and to provide an opportunity and a platform to grow and empower our researchers, challenge each other, and use our diversity to unlock global problems. Our aim is to create a world-class, globally connected science community, delivering science on pasture-based livestock systems and value chains that addresses common challenges in agri-food productivity, competitiveness and sustainability.

While research collaborations between these four institutes are not new, this new partnership agreement provides an opportunity to embed earlier *ad hoc* activities in a more strategically targeted way that will lead to lasting collaboration and new innovations.

The objective of the partnership is to work together to address common issues in the grassland sector and to provide an opportunity and a platform to grow and empower our researchers, challenge each other, and use our diversity to unlock global problems.

## Strategic themes

Given the enormity of the topic, the participating organisations identified six high-level themes around which to focus their research and collaborative activities. The six themes are: pasture and animal performance; environmental data and decision-making; meat quality; genetic performance; business models; and, research to impact.

### Theme 1: use of pasture and performance data

This theme focuses on the application and use of data, tools and methods to improve farmer decision making about grassland use, so as to optimise tactical and strategic choices. It aims to leverage the science capabilities among the strategic partners to combine data and

knowledge on a variety of pasture types and low cost/input systems so as to identify novel ways to improve grassland efficiency in a sustainable way.

#### **Theme 2: use of environmental data**

This theme focuses on providing data and tools to enable farmers to better understand how their decisions impact environmental outcomes on their farms (e.g., biodiversity, GHG emissions, carbon storage, water quality) as well as on their own economic, social and environmental values. It aims to leverage the science capabilities among the strategic partners to capture data on diverse environmental outcomes and grazing systems to produce better environmental outcomes.

#### **Theme 3: increased value from enhanced meat quality**

This theme focuses on adding value to grass-based production systems by increasing the quality of meat. It aims to leverage the science capabilities among the strategic partners to characterise the parameters of eating quality of meat from grazing production systems that are relevant for consumers in the participating countries. Another aim is to promote innovative post-mortem systems to improve quality.

#### **Theme 4: genetic performance**

This theme focuses on improving the genetics and breeding of both grass and animals by developing an international reference population. It aims to leverage the science capabilities among the strategic partners to capture and utilise data on growth, body score condition, carcass classification and quality, etc., and to share genomic, phenotypic and pedigree information among participating countries.

#### **Theme 5: business models that will add value**

This theme focuses on the need to develop new business models, both on farm and along the value chain, that will enable the agri-food sectors to exploit opportunities and facilitate change in the emerging bio and circular economies. It aims to leverage the science capabilities among the strategic partners to develop new business models for sustainable development.

#### **Theme 6: research to impact**

This theme focuses on ensuring that science delivers outcomes and impact by developing appropriate processes and tools to measure progress. It aims to leverage the science capabilities among the strategic partners to share knowledge, learning and experience of different approaches to outcomes that lead to impact, and to build synergies across the participating organisations.

#### **Activities to date**

Considerable progress has been made in the past six months to turn the high-level themes into collaborative research projects that will add value to the work already underway in each organisation. Each theme has a working group and the members of each group are currently collating research and expertise across the four partners and developing research proposals.

Workshops are planned for each of the other research themes in 2018, where collaborating researchers will develop proposals and plans for their projects.

In November 2017, the working group for theme 6: research to impact, led by James Turner (AgResearch), held its first workshop at Teagasc, Oak Park. The workshop was facilitated by Toni White and Helen Percy (AgResearch), and Kevin Heanue (Teagasc), and was attended by representatives from each of the partner organisations. The workshop focused on developing a research proposal to answer the fundamental question: how will we know if research and science is delivering its intended impact? Workshops are planned for each of the other research themes in 2018, where collaborating researchers will develop proposals and plans for their projects.

#### **Strategic partnership structure**

The strategic partnership consists of a Board made up of the chief executives of the participating organisations and an implementation team consisting of representatives from each of the partner organisations: Liz Wedderburn, AgResearch; Jane Kavanagh, Teagasc; Veronica Musselli, INIA; and, Eliecer Lopez, IRTA. The Executive Co-ordinator, Dr Gina Lucci of AgResearch NZ, is responsible for promoting, planning, co-ordinating, monitoring and evaluating the activities of the partnership in collaboration with the Board. Since commencing her role in February 2017, Gina has travelled to Uruguay, Spain and Ireland to co-ordinate the development of the research programmes and activities, to exchange information and training, and to gain a better understanding of the strengths of each organisation and how they operate. In addition, Gina and some of the board members met with DG Research and Innovation (Bioeconomy Directorate), DG Agriculture and Rural Development (Research and Innovation Unit), the New Zealand Ambassador to the EU, and the Uruguayan Ambassador to Belgium in Brussels in September to promote the partnership and discuss funding opportunities.

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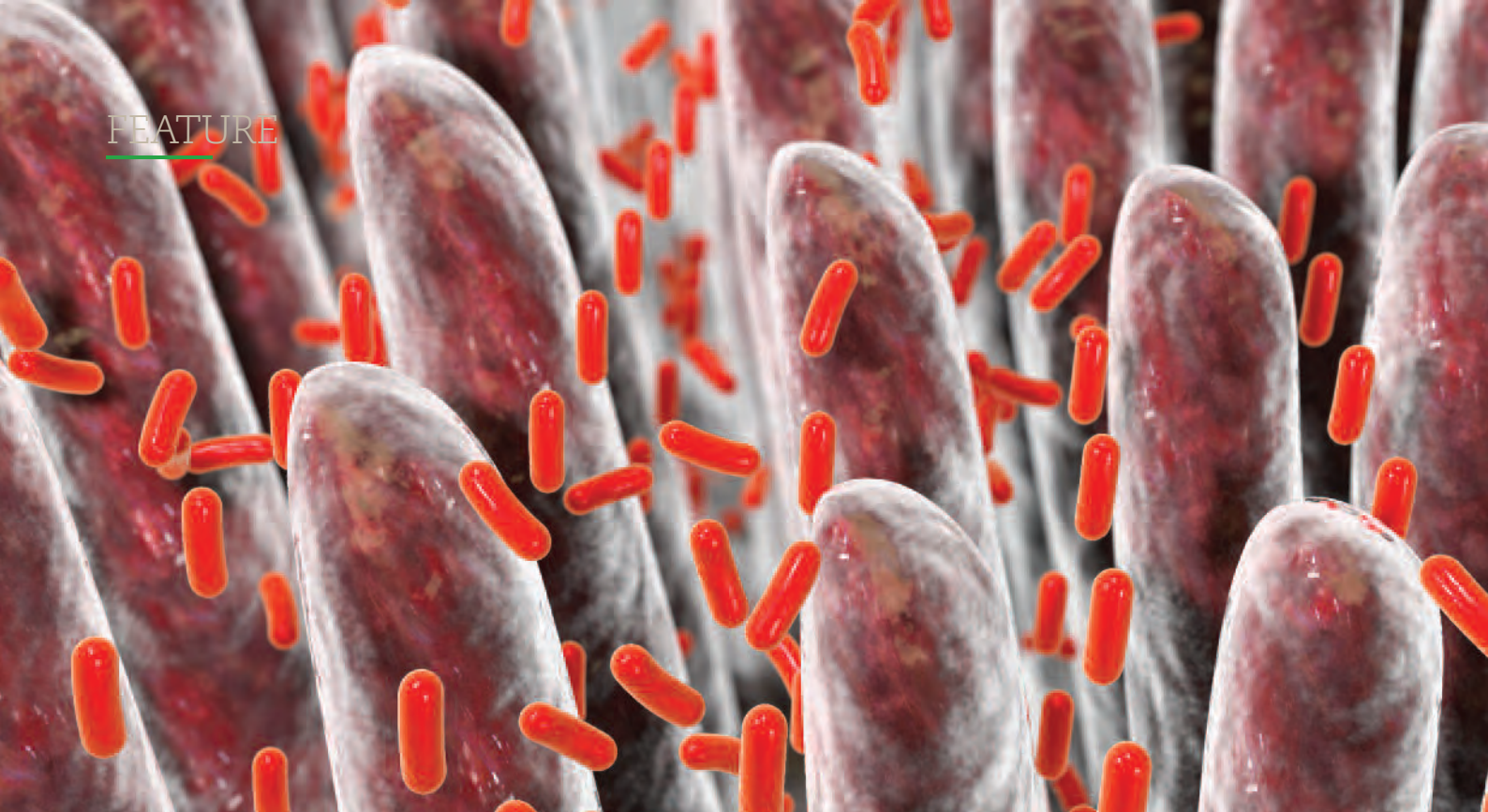
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# Milkybiotics

Sinead Morrin won Best Oral Presentation and the RDS medal at the recent **TEAGASC** Walsh Fellowships seminar, along with Best Food Research Presentation, and the Institute of Food Science and Technology Ireland medal, for her presentation on ‘Milkybiotics: influencing the intestinal surface to increase colonisation of health-promoting bacteria’.

The gastrointestinal tract is inhabited by microorganisms and the composition of these microbes can influence our health. Health-promoting bacteria, such as bifidobacteria, are abundant in the breastfed infant gut and are crucial for inhibiting the growth of pathogenic organisms, maintaining barrier function in the gut and promoting immunological and inflammatory responses. To confer these beneficial effects, the health-promoting bacteria must first be able to colonise the gut in sufficient numbers (Westermann *et al.*, 2016). Breast milk has been shown through many studies to allow the expansion of a beneficial gut microbiota (Gomez-Gallego *et al.*, 2016). For individuals with lower counts of these health-promoting bacteria, there are products available that promote the growth of these bacteria. However, there are no known products commercially available that increase the initial colonisation of these bacteria in the gut, which is the first and most important step when considering their ability to survive in the gastrointestinal tract. It may be the case that certain diets can modulate the intestinal epithelial cell surface, possibly resulting in changes in the abundance or type of attachment sites for bacteria (Angeloni *et al.*, 2005).

## Milk components to enhance gut colonisation

The aim of the study was to investigate the effect of selected milk components on modulating the intestinal cells to allow enhanced colonisation of health-promoting bacteria. After the intestinal cells were exposed to a bovine colostrum fraction, the adherence of a range of

commensal bacteria to the cells was dramatically improved (up to 52-fold) when compared to the non-treated control. Increases in colonisation were observed for all five common infant *Bifidobacterium* strains, strains which predominantly reside in the breastfed infant intestine. *Bifidobacterium adolescentis* ATCC 15703 and *Lactobacillus rhamnosus* GG, two adult health-promoting strains, also displayed increased adherence to the intestinal surface in the presence of the colostrum fraction.

## Monitoring cellular response

A systems-based approach was subsequently employed to monitor the response of the intestinal cells to the colostrum sample that involved transcriptomic, glycomic and proteomic analyses. Gene microarray analysis demonstrated differential expression of enzymes and proteins associated with glycosylation after exposure to the colostrum fraction. Genes involved in the enzymatic addition of terminal carbohydrate moieties (distinct part of molecule) to proteins such as transporters, transferases, glycosidases and lectins were found to be differentially regulated in the presence of the colostrum fraction. Lectin array studies also revealed an alteration in the abundance of terminal carbohydrate moieties with two monosaccharide moieties, N-acetylglucosamine and N-acetylgalactosamine, specifically present at higher levels on the cell surface when compared to the control. Further correlation was evident from the proteomic analysis, which revealed that proteins encoded by

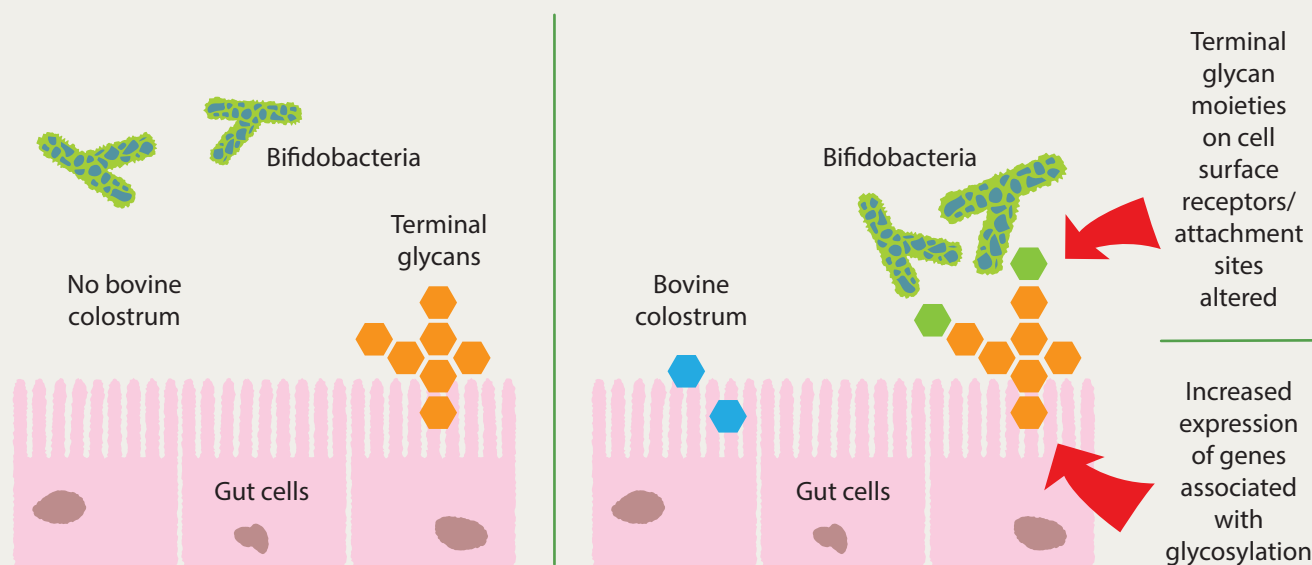


FIGURE 1: Mechanism of action of the bovine colostrum fraction.

these genes were being produced that ultimately confirmed a physical change was occurring at the intestinal surface. Currently, pathway analysis is being performed on the proteomic data, which may indicate the exact intracellular and extracellular cell signalling pathways involved in the response to the colostrum. Overall, the colostrum fraction altered the cell surface sugar pattern, thereby allowing more beneficial bacteria such as bifidobacteria to attach to the cells (Figure 1).

### New application for whey colostrum

This Teagasc-led research has identified a new application for whey colostrum and its components. This composition has potential for supplementation in infant formula or as food supplements for toddlers, and may improve the discrepancy of *Bifidobacterium* counts found between breastfed and formula-fed infants. It may also have potential as a method for treating or preventing diseases associated with lower counts of commensal bacteria such as inflammatory bowel diseases (Crohn's disease, irritable bowel syndrome, ulcerative colitis), periodontal disease, rheumatoid arthritis, atherosclerosis, allergy, multi-organ failure, asthma, and allergic diseases. Overall, this study provides an insight into how these bacteria colonise the human gut and highlights the potential of milk and other dietary components as functional ingredients that can potentially increase commensal numbers in individuals by conditioning the intestinal surface, allowing subsequent colonisation. A patent application has recently been filed, claiming novel enriched compositions, based on whey colostrum, for supplementation in infant formula, and products for elderly or immune-compromised individuals, or individuals on antibiotics.

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# Collagenius

Zhuning Wu won best poster at the recent **TEAGASC** Walsh Fellowships seminar for her presentation: 'Biophysical, biochemical and biological properties of pepsin soluble type-II collagen from mammalian and marine tissue sources for cartilage regeneration'.

## Introduction

Investigating high-value, biomedical opportunities for meat co-products will contribute to the sustainability of the Irish meat processing sector. These co-products are essentially the non-meat components arising from meat processing (e.g., offal, cartilage) and are often rich sources for proteins, with applications in a variety of fields including tissue engineering. Tissue engineering involves generating bioactive scaffolds and combining them with cells with a view to producing replacements for damaged tissue. The worldwide market for tissue engineering is expected to grow from \$7bn in 2016 to over \$16bn by 2023, with a compound annual growth rate (CAGR) of 13.2%.

Articular cartilage is a layer of smooth, white tissue that covers the ends of bones where they meet to form the joint. Healthy articular cartilage helps joints to maintain flexibility with a low frictional coefficient. Since articular cartilage is a low metabolic tissue, devoid of blood vessels, lymphatics and nerves, cartilage generation following trauma and degeneration presents a difficult clinical issue. Current treatments include multiple drilling, abrasion arthroplasty, mosaicplasty, and autogenous and allogeneic chondrocyte transplantation. Advances in tissue engineering provide new choice for articular cartilage regeneration.

Healthy articular cartilage helps joints to maintain flexibility with a low frictional coefficient.

## Predominant component

The extracellular matrix (ECM) is a complex of cross-linked proteins and macromolecules, which serves as a scaffolding or supporting matrix for cells in tissues and organs; in cartilage these cells are called chondrocytes. In addition to its structural role, it plays a key function in cellular communications and regulation, providing biophysical, biochemical and biological cues that are required for cell and tissue homeostasis. Cell adhesion (the process by which cells interact with each other or attach to a surface or substrate), proliferation and differentiation, or specialisation, are common functions. Collagen is the predominant component of the extracellular matrix in various connective tissues, and makes up 25% to 35% of the whole protein content in the body. A total of 29 types have been identified to date, with type II playing a particular supporting role in cartilagenous tissue, and is the major component of articular cartilage in the knee joint. From a tissue-engineering perspective, collagen possesses excellent



tissue compatibility, non-toxicity, and controllable biodegradation. In addition, its degradation products are absorbed easily without giving rise to an inflammation in the body. Collagen-based medical devices have been growing in value over the past decades in the tissue engineering field, providing treatment for focal defects of articular cartilage and a 3D matrix to support generation of chondrocytes from adipose-derived stem cells.

Therefore, the potential of an implantable type-II collagen sponge as a cell carrier for cartilage regeneration is being investigated in this project. We propose to isolate and characterise type-II collagen from porcine cartilage and cartilaginous fish through pepsin digestion, and test its usefulness in cartilage regeneration. A number of tests need to be carried out on the collagen to test its suitability for this use. These include physical assessments of the protein and also testing of how the collagen will function or react when implanted as a collagen sponge.

Using a variety of sources, namely male and female porcine trachea, auricular, articular cartilage and cartilaginous fish, collagen was extracted through acid-pepsin digestion at 4°C. Sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) was performed to assess the purity of the extracted collagen solution, and to uncover the number and size of collagen chains. Results confirmed the purity and molecular weight of collagen polypeptide chains, as compared to commercially available collagen. High purity type-II collagen was obtained from both male and female articular cartilage and cartilaginous fish material.

### Fabricating sponges

Collagen sponges were fabricated by dissolving the material in acetic acid and freeze-drying at -80°C. 4-arm polyethylene glycol (PEG) succinimidyl glutarate (4SG, Mw 10,000) was used as a crosslinking agent to fabricate collagen sponges. The structure of collagen sponges was determined by scanning electron microscopy (SEM) and the images obtained verified that the necessary homogenous porous structure was obtained. The porous structure allowed cells to attach and grow in the three-dimensional scaffold.

Thermal stability was tested by differential scanning calorimetry (DSC). Thermal stability reveals the integrity of collagen under non-crosslinked and crosslinked conditions, and the stability of potential collagen biomaterials at body temperature. Higher denaturation temperature of collagen indicates higher thermal stability, which is a critical characteristic of collagen-based medical devices. The thermal transition curves displayed similar denaturation temperatures of extracted non-crosslinked collagen samples, while the crosslinker significantly increased thermal stability, indicating an improvement in denaturation temperature of collagen biomaterials.

Enzyme degradation assays demonstrated the degradation profile of collagen biomaterials and their resistance to enzymatic digestion by collagenase. Collagen isolated from male and female articular cartilage exhibited relatively higher resistance against enzymatic degradation compared to male and female tracheal and auricular cartilage groups. A significant increase against enzymatic degradation can be observed in all crosslinked groups.

To test the biological properties of collagen sponges, i.e., how cells proliferate and differentiate in collagen sponges, human adipose-derived stem cells were seeded onto collagen sponges and cultured for 21 days. All groups of collagen sponges supported the proliferation and chondrogenic differentiation of human adipose-derived stem cells. Immunocytochemistry was carried out to visualise the expression of chondrogenic-specific protein using antibodies capable of binding to the protein of interest. To characterise the gene expression as a consequence of chondrogenic differentiation, reverse transcription polymerase chain reaction (RT-PCR) was performed to detect mRNA expression of chondrogenic marker genes. Results indicated that collagen sponges have potential to regenerate cartilage-like scaffolds. An upregulation of chondrogenic markers was evident. This research demonstrates that porcine articular cartilage and fish cartilage yield high-purity type-II collagen, which supports high-value biomedical applications for the meat processing sector in Ireland.

### Acknowledgements

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# Plasma: from the Northern Lights to agri-food's future technology

Researchers at **TEAGASC**, DIT and PlasmaLeap Technologies are leading the way in cold plasma research, where physics and biology meet.

Plasma is big stuff; in fact, it makes up 99.999% of the visible universe and is the fourth state of matter. However, unlike the other states of matter, plasma generally does not naturally exist on Earth under everyday conditions, apart from events such as the Northern Lights. Hence plasma must be artificially generated from neutral gases. Making plasma involves gas ionisation where free electrons are accelerated by an electric field, which collide with gas molecules, and consequently free additional electrons. Those electrons are in turn accelerated and free more electrons. The result is an avalanche multiplication that permits electrical conduction through the gas. This process is called the Townsend discharge, named after Irish physicist John Sealy Townsend, who discovered the fundamental mechanism of ionisation. The discharge requires a source of free electrons and a significant electric field; without both, the phenomenon does not occur.

## Applications for the agri-food sector

A perusal of the scientific literature points to a surge in interest in plasma applications in the agri-food sector. One of the key advantages of employing plasma technology in such applications is the unique cocktail of short-lived reactive species it provides. The potential applications of plasma technology are extensive and include: microbial decontamination; food shelf life extension; pest control; toxin elimination; food and package functionalisation; plant fertilisation; and, many others (Sarangapani *et al.*, 2018). We can expose biological matter to a direct plasma discharge and/or the resultant 'after-glow' of reactive species it provides (**Figure 1**). A relatively new approach for the delivery of plasma-generated species to biological targets is to 'activate' water or other liquids through exposure to plasma discharges (**Figure 2**). This results in plasma-activated water (PAW), which can be used as an active washing agent or bio-fertiliser. Such an approach is advantageous for its ease of application, defined dose, storability and off-site generation. PAW displays, for a period of time, reactive properties which may be used for either disinfection of the water itself or as a wash agent for surfaces. Exciting areas of plasma agri-food research include food preservation, agriculture, and food odours and waste.



FIGURE 1: In-package plasma treatment of chicken meat.

## Food preservation

Many of the plasma species generated are highly reactive and plasma is often cited for its multi-modal mechanisms of antimicrobial action. Plasma species have a broad spectrum of lifetimes (nanoseconds to hours) dependent on both plasma conditions and available reactive matter such as organic material. This leads to a useful window of activity with regard to plasma treatment and afterwards the conversion of plasma species into inert gas (Sarangapani *et al.*, 2018). Exposure of foods to plasma gas species or washing in PAW can significantly extend the shelf life of foods. In particular, we are interested in replacing processes such as chlorine washes with such technologies, as the efficacy is similar but the process does not leave any chemical residues.

## Agriculture

Plasma discharges and PAW can be used for plant growth (as a cheap nitrate fixation process) and also as a bio-pesticide. As the process uses only atmospheric air it can be considered an environmentally sustainable and economically viable technology. **Figure 3** shows the effects of using PAW on the growth of soybean plants. Plasma also dramatically enhances the germination rates and vitality of plant seeds. Plasma is also a promising technology for control of pests in stored cereal crops and as an environmentally friendly bio-pesticide for plants in the field (Misra *et al.*, 2016).

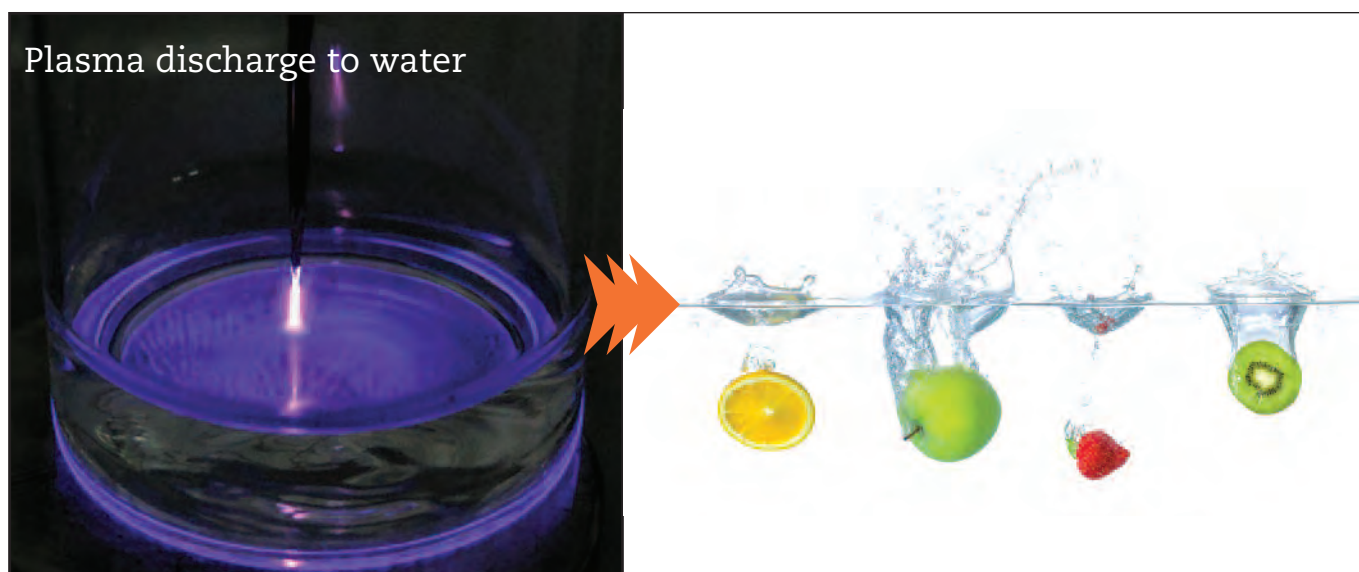


FIGURE 2: Making plasma-activated water (PAW) and product immersion in PAW.



FIGURE 3: PAW for soybean growth enhancement.

### Food odours and waste

Plasma can be used as an effective technique for industrial and animal house odour treatment. Teagasc, in conjunction with the BioPlasma group at Dublin Institute of Technology, are currently developing a plasma technology for odour breakdown, which is funded by Meat Technology Ireland (MTI). Reducing food losses and waste is identified as a global challenge. Recently, the feasibility of using the technology for biological waste pre-treatments has attracted attention. Our initial study demonstrates delignification in spent coffee waste leading to a suitable substrate for bioethanol production (Ravindran *et al.*, 2017).

Plasma species have a broad spectrum of lifetimes (nanosecond hours) dependent on both plasma conditions and available reactive matter such as organic material.

The unique physics and chemistry found with cold plasma offers agri-food industries a new technology-driven tool for supporting a sustainable food industry. Technology developments offering the potential for process scaling coupled with the use of only

atmospheric air as the inducer gas means that plasma is both technologically and economically viable as a food and agri processing aid (Sarangapani *et al.*, 2018). Irish research and technology companies including Teagasc, DIT and PlasmaLeap Technologies are leading the way in this new field of research, where physics and biology meet.

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# New value-adding tools

New research from **TEAGASC** looked at transforming readily available big data into value-creating decision support tools.



The 'datafication' of the agri-food sector is presenting new challenges, not least of which is how to encourage smarter and better-informed decision making from the vast quantity of data originating from multiple sources. We know that the observed performance of an individual is a function of its DNA and the environment it has been exposed to. Geneticists have therefore preoccupied themselves with developing advanced statistical and mathematical methodologies to disentangle the genetic effects from environmental effects, and in the process, generate accurate estimates of the genetic merit of the individual. What have received less attention, however, are the support systems available for breeders and farmers to aid in value-generating decision making. In collaboration with the Irish Cattle Breeding Federation (ICBF), Teagasc geneticists at the Animal & Grassland Research and Innovation Centre, Moorepark, have embarked on the development of three complementary animal-level tools to assist on-farm decision making. These tools exploit readily available data on a large scale, and are equally applicable in dairy cattle, beef cattle and sheep.

## Cow's own worth

Candidate dairy dams of the next generation are currently selected based on the Irish national breeding goal, the Economic Breeding Index (EBI). Animal-centric characteristics other than genetic merit, however, also affect the remaining lifetime profitability of a female. The cow's own worth (COW) tool was developed by Teagasc to rank females for use in culling decisions. It bases its ranking on prediction of a cow's remaining lifetime profitability, accounting for animal-specific factors such as age, level of heterosis, calving date and environment, as well the genetic merit of both the female herself and her female progeny. The index consists of three modules per female: 1) her expected profit in the current lactation; 2) her expected profit in her remaining lactations; and, 3) the net cost of replacing her with a heifer. Each female receives a calculated value based on the sum of the three components and is ranked within

herd accordingly. The index is run 'on the fly' from the ICBF database via the farmer's personalised web service. The algorithms developed at Teagasc supporting the back end of the system exploit up-to-date information recorded within the database of the dairy females for a range of performance traits, as well as forward predictions on future functionality within the herd. Farmers are encouraged to input additional data such as health events and pregnancy diagnosis. Once inputted, the algorithm can be immediately re-run by the farmer and updated rankings will be provided. Use of the index in culling decisions has been shown to increase profit on farm. In the six weeks since its launch in October 2017, over 3,800 unique farmers have run the COW for their herd. A COW is now being developed for beef herds.

What has received less attention, however, are the support systems available for breeders and farmers to aid in value-generating decision making.

## Sire mating advice

Genetic gain is based on the principle that the mean performance of the current generation should be superior to that of previous generations. In pursuit of this, breeders wish for the genetic merit of progeny from a given mating to be superior to both parents. However, genetic gain is also predicated on the availability of usable genetic variability. The objective of mating advice is to identify the most complementary match between all possible candidate parents to produce high genetic merit offspring. This



often has to be achieved within the confines of some parameter space (e.g., number of matings per cow and per sire), but also respecting some of the predefined criteria specified by the farmer. Teagasc geneticists have developed new algorithms constituting the back end of the revamped ICBF sire mating advice system to be launched for the 2018 breeding season. The algorithms are based on linear programming, which is a mathematical approach to maximise a function given a particular set of constraints. Furthermore, DNA information is now, for the first time, included in the mating advice tool, providing not only a more accurate estimate of the expected genetic merit of the progeny, but also a better estimate of the pairwise relationship among all candidate parents. Through a personalised web interface developed by the ICBF, the farmer specifies the sires(s) available to use and their proportional use in the herd. The output from the algorithms, which is downloadable, is a list of the recommended male–female matings to maximise genetic gain, as well as the expected reliability of the bull team used.

### BLUPs v BLUEs

Irrespective of trait or species, genetic evaluations disentangle the observed performance of an individual into its genetic merit (termed best linear unbiased predictions (BLUPs)) and the contribution of environmental effects such as herd or flock (termed best linear unbiased estimates (BLUEs)). Animal breeders have almost exclusively focused on BLUPs, with each animal receiving its own BLUP, often called estimated breeding value (EBV) or predicted transmitting ability (PTA). BLUEs, which are analogous to an EBV for each herd, have received less attention. The incorporation of BLUEs within on-farm support tools can enable the evaluation of herd-level management by assessing the actual performance of the herd. Advisory services can therefore benefit from comparing the mean BLUPs and BLUEs of a herd to diagnose any herd-level issues. Such information can be used to improve Teagasc's advisory services through more tailored advice

for individual farmers based on the farm-specific factors contributing to the observed performance.

### Acknowledgements

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# Meeting the challenges of labour demand on farm

**TEAGASC** research is looking at levels of labour input on Irish dairy farms and identifying strategies associated with increased efficiency.

## The labour issue on farms

Dairy herd size in Ireland has increased in recent times following the abolition of the EU milk quota regime. The percentage of dairy herds with greater than 100 cows has increased from 4.5% in 2005 to 23% in 2016 (Teagasc, 2017). This change in profile has resulted in an increased labour demand on farms. Labour has been identified as one of the highest costs on pasture-based dairy farms (Hemme *et al.*, 2014). Ireland has historically had low milk production per labour unit. Hence, optimisation of on-farm labour efficiency is vital for sustainable herd expansion. The objective of this study was to quantify levels of labour input and labour efficiency on commercial dairy farms, and to identify the facilities and management practices associated with increased efficiency.

## Measurement of labour input on dairy farms

Thirty-eight dairy farms were enrolled on the study, and data was collected over three consecutive days each month during a 12-month period between 2015 and 2016. The mean herd size was 187 cows (range 79 to 533), and all herds had previously been

identified as labour-efficient farms by Teagasc dairy advisors. Data collection was achieved through use of an app on a smartphone. Other data, including other farm labour (family or hired), hours of machinery work (with the farm's own equipment or contracted), cow numbers, and facilities and management practices were collected through online and phone surveys. For analysis purposes, farms were categorised into one of three herd size categories (HSCs). Categories 1, 2, and 3 constituted farms with <150 cows (HSC 1), 150-249 cows (HSC 2), or ≥250 cows (HSC 3).

## Labour demand and efficiency levels

Overall, farm labour input increased with HSC, with 3,015 hours, 4,499 hours, and 6,023 hours worked per year on HSCs 1, 2, and 3, respectively. A greater proportion of work was carried out by hired labour units as herd size increased (**Figure 1**). Labour efficiency was measured as total hours of labour input to the dairy enterprise divided by herd size. Labour efficiency was similar for HSCs 1 and 2 (23.8 and 23.3h/cow per year, respectively), but improved as herd size increased above 250 cows (17.3h/cow per year for HSC 3).



Thirty-eight dairy farms were enrolled on the study.



The most efficient farms were getting calves contract reared.



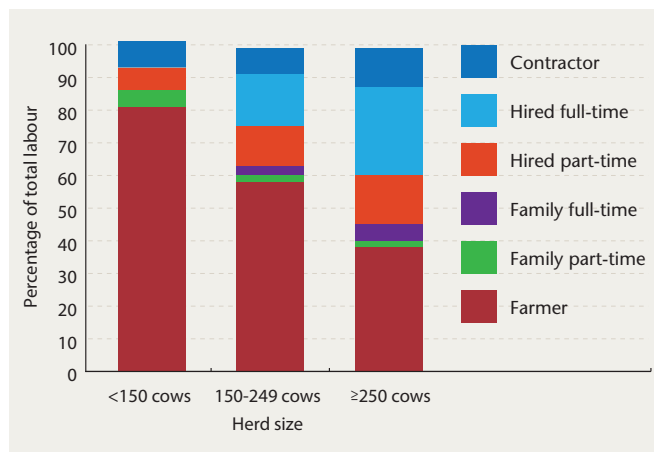


FIGURE 1: Proportion of labour performed on farm by different personnel across HSC 1 (<150 cows), HSC 2 (150-249 cows), and HSC 3 (≥250 cows).

There was, however, a wide range in efficiency within each herd size category; individual farms in HSCs 1 and 2 achieved 12.6h/cow per year and 13.9h/cow per year, respectively, indicating that smaller farms can be extremely efficient.

### Impact of facilities and practices

The most time-consuming tasks were milking (33% of total farm hours) and those associated with winter feeding (17% of total farm hours). The most efficient farms (top 25%) had, on average, nine rows of cows to milk, had an automatic backing gate present, and performed once-a-day milking for at least four weeks in the springtime. Conversely, the least efficient farms (bottom 25%) had, on average, 11 rows of cows, no automatic backing gates, and did not perform once-a-day milking at all in the spring. Teat preparation practices were similar on the most and least efficient farms, and no differences in somatic cell count were observed. With regard to winter feeding, the most efficient farms had fewer areas to feed cows and heifers (three areas as opposed to four areas), delivered fresh feed every second day (as opposed to every day), and delivered feed with a tractor/shear grab (as opposed to feeding with a tractor/finger

grab and feeder wagon). While labour input attributed to calf rearing did not represent a large proportion of yearly labour, its seasonal nature meant that time dedicated to this task needed to be investigated. The most efficient farms were getting calves contract reared. Aside from the farms that were contract rearing, there were various noteworthy differences between calf-rearing practices on the most and least efficient farms. The most efficient farms fed colostrum via stomach tube, did not house calves in individual pens, and got calves out to grass at six weeks old. In contrast, the least efficient farms relied on colostrum intake through a combination of suckling and/or bucket and teat, calves were more likely to live on an out farm, calves were more likely to be housed in individual pens, and were going out to grass at nine weeks old.

When hours spent at machinery work were investigated, the most efficient farms had, on average, 600 hours of work, approximately half of which was performed by contractors and half by the farm's own personnel and equipment. The least efficient farms performed approximately 1,200 hours of machinery work, with 75% of those hours performed by the farm's own personnel and equipment.

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## Take home message

This study identified three key findings:

- labour efficiency improved as herd size increased above 250 cows, but there was an associated requirement of additional hired labour in these herds;
- adopting appropriate technologies and management practices associated with milking and calf care had a favourable impact on labour efficiency; and,
- high levels of labour efficiency were not solely associated with large herds, and were also achieved on herds with <150 cows.

# Understanding spores in dairy products and processes

**TEAGASC** Food Research Centre, Moorepark, in collaboration with Tyndall National Institute, are pushing the boundaries in understanding the fate of spore-forming bacteria in dairy processes including entry, survivability and identification.

The dairy industry in Ireland continues to expand its production capacities post the abolition of milk quotas in 2015, with the vast majority of our dairy produce destined for export markets. While there is unprecedented commitment and vigour in the industry, the challenges surrounding the maintenance of the high food safety standards for which Irish produce is known remains at the fore for those involved in the agri-food sector. Teagasc continues to support the Irish dairy industry in addressing a rapidly evolving food safety environment, and is currently leading a project in collaboration with Tyndall National Institute focused on identifying the key problematic spore-forming bacteria in Irish powdered dairy ingredients. The project looks at Spore Analysis Critical Control Points (SACCP) for their control in the dairy factory, and will provide applied research outputs to support the continued high level of food safety already prevalent in the industry. Through understanding the behaviour of spores in the dairy process, the SACCP project will minimise the risk of any future food safety scares.

## Quality by design or control

The question is often raised as to whether we should apply a philosophy in our industry of quality by design or quality by control. The SACCP project aims to address both of these questions by modelling the behaviour of highly heat-resistant spores during thermal processing in concentrated dairy streams, while also evaluating alternatives to high heat treatment such as filtration processes and emerging microwave volumetric heating technologies (Figure 1), as lower thermal load processes with higher spore eradication efficiency than conventional heating processes. To address control of microbiological quality in finished products, the project is developing next-generation molecular microbiology approaches that may in the future supersede classical microbiology methods currently used as industry standard for identification and quantification of heat-resistant spores. The SACCP project revolves around three thematic areas focused on microbiology, technology and sensors.

## Microbiology

Assessing the performance of existing classical microbiological methodologies for spore detection, it is clear that traditional culturing techniques are slow and provide little information without further investigation. Novel shotgun metagenomic sequencing allows detection and identification of possible pathogens and spoilage bacteria in parallel with strain level analysis and functional gene analysis, such as identification of toxin genes.

This approach has the potential to be of great value with respect to the detection of spore-forming bacteria, and could allow a processor to make an informed decision surrounding process changes to reduce the risk of spore contamination.

The continued development of next-generation sequencing techniques for the isolation and identification of spore-forming bacteria in both products and processes may form the basis for quality control laboratories in the dairy industry in the future.

## Technology

The SACCP project is assessing the survival of highly heat-resistant spore-forming microbes (*Geobacillus Stearothermophilus*) in pilot heat exchangers using model dairy systems (skim milk) at elevated dry matter contents, with the aim of understanding the protective effect of increasing dry matter contents on the survival of spores in dairy processes. Additionally, novel, state-of-the-art processes are being evaluated, such as microwave volumetric heating, as a potential new technology for control of spores in the dairy factory.

Because microwaves transfer electromagnetic energy at a molecular level, and the vibration of the molecules creates heat through friction, microwave heating could provide more effective spore inactivation at lower time temperature combinations than conventional methods of thermal processing. Current investigations are exploring the potential of microwave heating to reduce highly heat-resistant spore numbers within model dairy systems.

## Electrochemical impedance spectroscopy

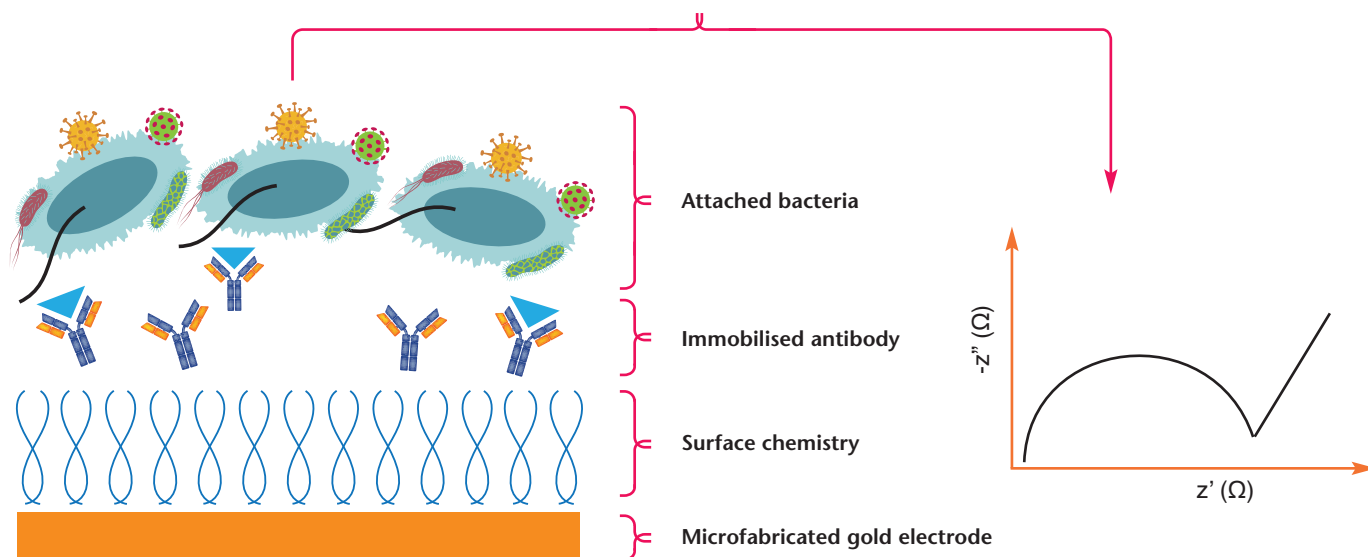


FIGURE 2: Proposed biosensor under development by Tyndall National Institute for detection of spores.



FIGURE 1: Microwave volumetric heating system being assessed in the SACCp (<http://www.advancedmicrowavetechnologies.com/equipment/>).

### Sensors

Tyndall National Institute is responsible for the development of biosensors that are specific to certain spore-forming bacteria. An electrochemical-based approach is being used, which facilitates the design and fabrication of miniaturised and disposable sensing chips. The sensor consists of a three-electrode cell: a working electrode, counter electrode and reference electrode. The Tyndall group is focused on the design and demonstration of electrochemical biosensors capable of being used 'at-line' during dairy processing, which can identify and quantify spore-forming bacteria in real time. The sensor design employs what is known as the lock and key approach whereby a particular 'agent' that responds only to the presence of the target 'agent' or organism is attached to a solid electrode. When an appropriate spore arrives at such a surface it attaches via quite strong chemical bonds that can only form between the spore, which may be called the 'antigen', and the adsorbed bioactive species, which may be called the 'antibody'. So, the detection of the spore in this instance will occur via the selective binding of the target organism to the specially prepared electrode surface using a method known as electrochemical impedance spectroscopy (Figure 2). While the complete elimination of spore formers from the dairy supply chain will remain an area of continuous improvement, the successful delivery of the SACCp project will help to future-proof food safety for the

dairy industry by seeking state-of-the-art solutions for the detection and eradication of spore-forming bacteria within the processing chain.

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Members of the AgriSpin cross visit team interview farmer Thomas O'Connor about the farm partnership on his farm.

# AgriSpin – supporting innovation

**TEAGASC** was a partner in the EU-funded AgriSpin project, which aims to strengthen agricultural innovation support systems.

Support services for agricultural innovation are context dependent and there is no 'silver bullet' solution that is always appropriate across different countries, types of innovation or farming systems. However, we now have a far better understanding of agricultural innovation support services, how they link with innovation processes, and ways to strengthen such activities so as to underpin 'best-fit' innovation support services (ISS).

These were some of the high-level conclusions of the recently completed Horizon 2020-funded project 'AgriSpin – Space for Innovations in Agriculture'. The project, in which Teagasc was a partner, sought to identify best practices for innovation and ISS in European agriculture and was delivered by a consortium of 15 partners from 12 countries over two and a half years beginning in March 2015.

## Exploratory case studies

The AgriSpin project took an action-research approach using exploratory case studies. Data was gathered on practical innovation experiences using a series of 13 cross visits to 12 countries, during which multi-actor teams of AgriSpin partners consisting of between seven and 10 researchers, practitioners and policy makers studied three to four innovation cases identified by the host partner. Each cross visit lasted three to four days, during which the visit team interviewed key actors, visited farms and firms, and engaged in collective analysis of the data gathered during the visit. As a result, a rich database of 57 cases across Europe, focusing on innovation processes and how to support them, was developed and analysed. The methodology for conducting the cross visits centred on the use of the spiral of innovation (**Figure 1**).

When analysing an innovation, the cross visit team focused on understanding the actors involved at each stage in the spiral, the activities carried out, the pitfalls encountered, the barriers overcome and the particular help needed. It was critical to identify at what stages the support was offered, what the support entailed, and how it helped to move the innovation process on to the next stage.

## Key findings

Across the 57 cases, the different roles of innovation support providers at different phases of the innovation process are outlined in **Table 1**.

**Table 1: Role of ISS in different phases of the innovation process.**

Innovation phase	Role of innovation support service providers (ISSP)
<b>Early phase</b> (e.g., initial idea, inspiration, planning)	Provide space and resources for key actors to interact and establish relationships through sharing knowledge, motivations, etc.
<b>Final phases</b> (e.g., development, realisation, dissemination and embedding)	Service provision is more standardised, with many services oriented to farmers to ensure the scaling up and embedding of the innovation.

The diversity and intensity of innovation support needs depend on two dimensions: the level of technological change required to achieve the innovation; and, the level of attitudinal and organisational change needed to co-ordinate the innovation actors. In addition, as support services may be provided by a large range of service providers, the ISS depends on their characteristics (e.g., their mandate, reputation and resources). The mechanisms used to align the ISS to fully support innovation are largely dependent on the degree of concentration or fragmentation of the ISS. Networking, facilitation and brokerage functions are crucial for all actors across all phases of the innovation process. Notwithstanding the need to draw general conclusions, the case studies confirm that ISS remain case specific and, therefore, recommendations to improve them are concerned with 'best fit' as opposed to 'best practice'.

In Ireland, three diverse cases were studied during a cross visit: 'Bovine Economic Breeding Index'; 'Collaborative Farming'; and, sustainable beef production from the 'Greenacres Calf to Beef Programme'. All three were considered to be excellent multi-actor cases, well established and



Figure 1: Spiral of innovation.

supported by science and intermediary services. The degree to which they demonstrated the value of institutional support was noted. It was also noted that in the Irish context, innovation support could exploit the creativity of actors more. Thus the question was asked: "Could the dependency relationship of strong Teagasc-centric support be improved by more interdependence among actors?"

### Key conclusions from AgriSpin

There were five key cross cutting conclusions from the project:

- Communication, negotiation, networking and co-operation skills of actors are increasingly important for successful innovation support processes.
- The capacity of ISSPs or innovation brokers to form and maintain networks with practitioners to support innovations at the territorial or value chain scale is decisive for successful innovation. A specific skillset for innovation brokers was identified and a training programme has been developed to impart those skills.
- Service provision is dependent on the institutional context and especially on how fragmented or concentrated the agricultural knowledge and innovation system (AKIS) is in each country/region.
- The personality traits of support actors (e.g., responsiveness, empathy and awareness) towards innovators are key characteristics that link them with innovators, create conditions of social embeddedness and provide the breeding ground for trust to be developed.
- Above all, the role of funding bodies is imperative in creating an enabling environment for both service providers and innovators with regard to funding opportunities, management and the general approach towards innovation.

### Acknowledgements

The authors would like to particularly thank the Irish farmers, farm families, advisors, policymakers, industry stakeholders and Teagasc colleagues who contributed to the AgriSpin project. Also our partner colleagues within the AgriSpin project whose work this article also draws upon. The AgriSpin project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 652642.

### Further information

For more information on AgriSpin, including innovation resources, see: [www.agrispin.eu](http://www.agrispin.eu).

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# Automatic detection of forest disturbance by satellite

A new piece of software, IForDEO, has been developed by TEAGASC, which uses satellite images to automatically detect forest disturbance.

The Department of Agriculture, Food and the Marine-funded project, CforRep, led by UCD with partners in University College Cork, University of Limerick and FERS Ltd., aimed to improve Ireland's reporting of the forest carbon budgets and how they change. Teagasc's role was to estimate a baseline for forest cover in 1990, devise a method for detecting disturbance in the current forest cover, and to build a system to remotely monitor forestry. Disturbance of forestry is important (whether planned like felling or thinning, or unplanned like storm damage), as the disturbance events can possibly alter the carbon stored in the forest soils. Our partners are experimenting to see exactly how soil carbon pools are disturbed, and in Teagasc we are using remote-sensing satellites to detect that disturbance.

## Software for analysing forestry cover

Remote-sensing satellites orbiting the earth continually record images of the surface below. These images are not only recorded as conventional visible images, but the systems also measure non-visible components of the reflected sunlight. These multi-spectral images can be processed within specialised computer systems and the image pixels classified into different land covers. This is a multi-stage process that involves receiving raw image data, correcting and geo-coding, and quality control through to classification and assessment. The project needed to be able to track the lifecycle of every forest in Ireland from the 1980s using thousands of satellite images. This objective required that processes be automated. The software developed is an open source Python library of modules and scripts – IForDEO (Ireland Forest Disturbance from Earth Observation). The modules operate automatically to process, classify, and assess satellite images as they become available. Significant work was also put into creating a long-term archive of imagery from a number of satellite receiving stations across Europe, to create the historical image archive existing for the island of Ireland.

## Landsat archive

Every available image in the Teagasc Landsat Archive that was acquired between March 23 and October 10 (March 24 and October 11 in leap years; currently 2,345 images) is classified, along with any new imagery available from the United States Geological Survey (the system currently utilises LANDSAT (TM), ETM+, and OLI/TIRS data, and European Space Agency Sentinel-2 data will be incorporated in the next iteration). The data is quality controlled, re-projected into Irish Transverse Mercator (the geographic co-ordinate system for Ireland) projection, and checked for cloudy and cloud-shadowed pixels. All clear land pixels are classified, resulting in a time series of land covers from the year 1984 on for every pixel. This time series is processed for outliers using a series of statistical and logical rules (for example, a pixel can't go from forestry to urban to forestry over a month – clearly the urban classification is an error).

## National forestry inventory

The basic land use classifications are forestry, grassland, cropland, natural vegetation, and urban. Thus, the software can produce a basic land cover map for any year since 1984 and into the future. One important land cover map produced was in the year 1990. This year is important as it is the baseline reference year for land use change under the Intergovernmental Panel on Climate Change (IPCC) reporting protocols. Up until now, there was no land use data for 1990 of sufficient spatial resolution to act as a reliable reference for reporting land use change in Ireland. The IForDEO 1990 land use map allows us, for the first time, to estimate the land use of current forestry in the National Forest Inventory as it was in 1990 and, thus, improve our estimate of carbon sequestration achieved by the national forest planting programme. The final module in the IForDEO suite tracks activity within the Forest Inventory Parcel System (FIPS). The same process of classification and time series analysis is instead used to classify year-on-year activity within



### Forest cover change in the Ballyhoura Mountains

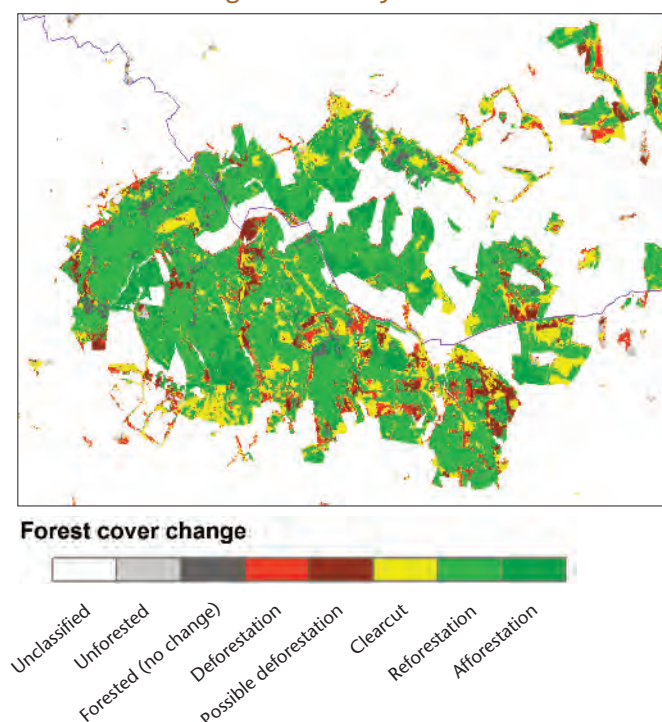


FIGURE 1: Landsat-derived 1990 land cover for forestry in the Ballyhoura Mountains, in counties Limerick and Cork.

forests. Because under IPCC accounting rules deforestation has a particular meaning (the permanent removal of forestry, not just the felling of trees), current activity in a forest plantation has to be assessed with reference to the previous ten-year period. Current forest conditions are classified as a number of states including continuing forestry, reforestation, and deforestation. Deforestation is classed where trees have been removed and there is no sign of replanting/regrowth within 10 years. Possible deforestation is where trees have been removed from an existing plantation less than ten years from the present, and accounts for situations where young forest canopies can be spectrally confused with grasslands or croplands due to the presence of visible understory vegetation (shrubs and plants growing under the main canopy of the forest). The software also maps the year of the last significant change.

#### State of the national forest

Teagasc and the Forest Service can now automatically produce an annual state of the forest map with little more than a touch of a button, though the full analysis can take a number of days to run.

With our partners in University College Cork, we are looking at integrating specialist synthetic aperture radar (SAR) imagery into our system. SAR is advantageous as unlike optical sensors, it can acquire data both during the day or at night, is unaffected by cloud cover, and is primarily sensitive to the geometric properties of the target. Thus, SAR is particularly useful for identifying the type of disturbance, e.g., distinguishing between felling and wind throw events.

In the future IForDEO will be adapted to use additional satellite data, including from SARs like Sentinel-1 and ALOS-2 PALSAR, and optical sensors like the ESA's Sentinel-2, DLR's EnMAP, and the NASA EO-1 Hyperion to improve our classification of current status. Furthermore, we

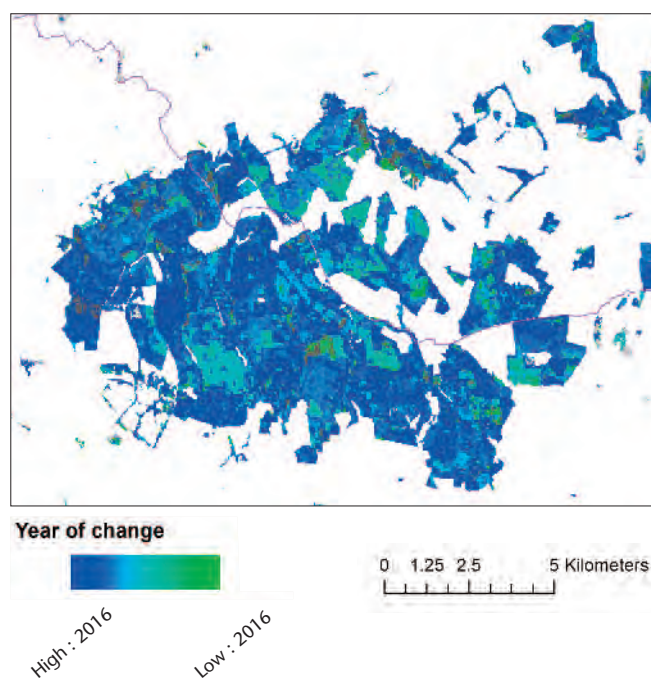


FIGURE 2: Type of forest cover change in the Ballyhoura Mountains (1985 to 2016), with date of most recent change.

will be adapting the process to look at grassland and cropland and other land cover/land use change dynamics. For details on the Landsat archive and scripts contact Guy Serbin at Teagasc Johnstown Castle.

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# For the public good

Data from the **TEAGASC** National Farm Survey is helping researchers to learn more about social and environmental sustainability on Irish small farms.

A recent report from the Teagasc National Farm Survey (NFS) on the sustainability status of small farms considered three dimensions: economic, environmental and social. Based on a special survey conducted in 2015, data were collected on a representative sample of farms producing an annual standard output of €8,000 or less (the equivalent of 14 suckler cows or 55 sheep), of which there are 52,000 farms nationally. Results indicate that three-quarters of small farms earned a farm income of less than €5,000. However, many of these farms are operated on a part-time basis with almost 90% of such households in receipt of an additional income source. Despite the low levels of profitability on these farms, 85% plan to continue farming, and as they are strongly embedded in the local economy they play an important role in supporting rural employment, managing the natural environment and maintaining the social fabric of rural areas. The existence of small-scale farms is not a uniquely Irish phenomenon; indeed, nine out of ten farms within the EU are less than 20 hectares. The recent communication from the EU Commission, 'The future of food and farming', reiterates the multifunctional benefits of farming to the wider rural economy, and the future objectives of the Common Agricultural Policy (CAP) are: to foster a smart and resilient agricultural sector; to bolster environmental care and climate action; and, to strengthen the socioeconomic fabric of rural areas. The shape of future policy reform will likely result in more targeted payments towards supporting smaller farms given their multifunctional nature and the important role that they play in the provision of public goods.

## Environmental sustainability

As stewards of the countryside it is important to demonstrate the environmental impacts of farming on air, soil and water quality, as well as its contribution to biodiversity. Two key indicators, namely farm-level greenhouse gas (GHG) emissions and farm nutrient balances, are considered here. GHG emissions were calculated using Intergovernmental Panel on Climate Change (IPCC) methodologies, as employed in the Irish National Inventory Report. Key farm structural and management details, such as livestock number and age and fertiliser

applications, are multiplied by relevant coefficients to estimate agricultural GHG emissions. As shown in **Figure 1**, small farms tended to have lower GHG emissions per unit area, for all systems. This is a result of small farms generally having low stocking rates, leading to low per hectare emissions from enteric fermentation and animal manures. These farms are managed more extensively, with lower fertiliser and lime applications. However, when expressed per unit of animal liveweight produced, small farms are relatively less emissions efficient, with greater emissions per unit of output. This is largely as a result of slower animal weight gain and longer animal lifespans on smaller farms. It should be noted, however, that the GHG accounting methods employed here do not include emissions from off-farm imports ('embedded emissions' in purchased fertilisers and animal feeds), which are generally higher on more intensive farms.

As stewards of the countryside it is important to demonstrate the environmental impacts of farming on air, soil and water quality, as well as its contribution to biodiversity.

Farm gate nutrient balances are calculated by subtracting the nitrogen (N) and phosphorus (P) contained in all agricultural outputs (e.g., livestock and livestock products sold) from all farm inputs (e.g., fertilisers, animal imports and purchased feed). This provides an estimate of the nutrient surpluses applied to each farm. High nutrient balances can indicate a risk of losses to water bodies, while very low nutrient values (near 0) can indicate a risk of degrading soil quality. Small farms generally had lower N balances on a per hectare basis, especially on sheep farms, indicating a lower risk of N pollution to local water bodies. Expressing the nutrient balances on a per unit liveweight basis shows

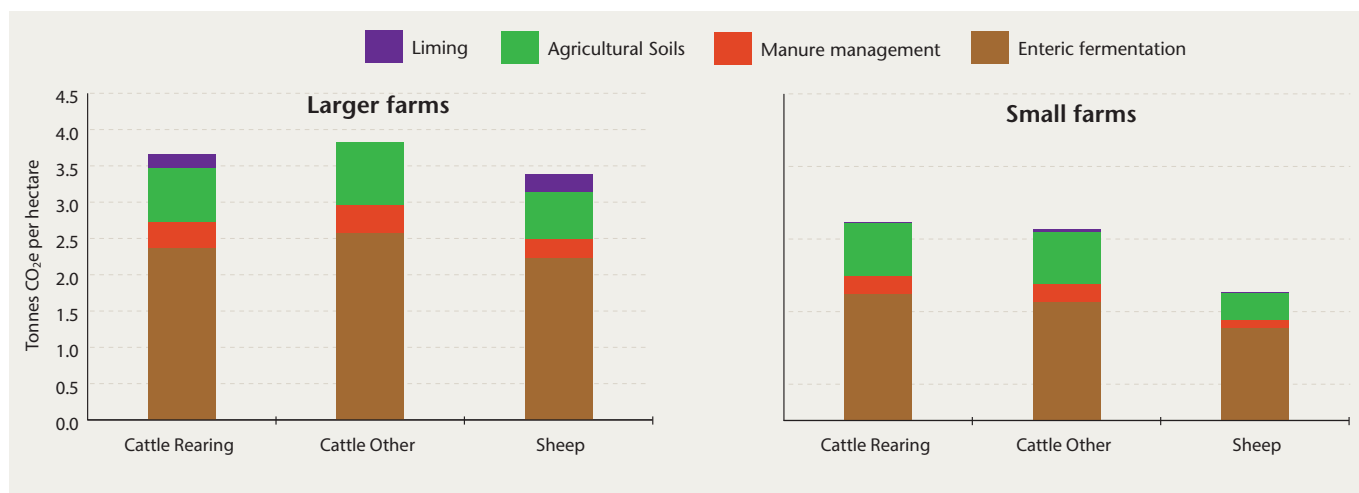


FIGURE 1: Agricultural greenhouse gas emissions per hectare. Source: Teagasc National Farm Survey.

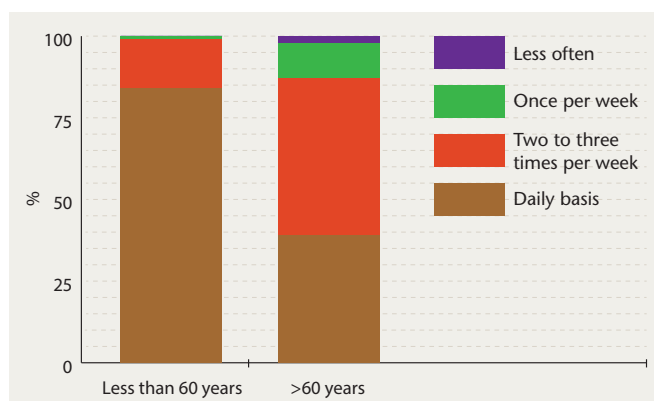


FIGURE 2: Frequency of contact with persons outside of household. Source: Teagasc National Farm Survey.

that smaller farms achieve greater animal weight gains for the quantity of excess nutrients applied, despite having lower outputs per hectare. This is because small farms are generally low-input, grass-fed systems, with lower N and P imported in animal feeds and lower fertiliser applications.

### Social sustainability

Challenges exist around the measurement of social sustainability given its subjective and broad nature, but the importance of issues such as rural viability and quality of life are increasingly recognised. Work is ongoing to build on the current suite of indicators considered within the Teagasc NFS across three broad categories: farmer well-being; rural well-being; and, animal well-being. The small farms survey revealed some stark statistics around the demography of these households, with one in four farm operators living alone and one in three aged over 65. Survey results showed a significant age effect around rural isolation, sense of security and access to services. **Figure 2** illustrates that 11% of farmers aged over 60 have contact with people outside of their household only once per week, compared to just 1% of younger farmers.

Similarly, farmers' perceived sense of security in their home is also negatively correlated with age, with 17% of older farmers reporting deterioration in their sense of security in the past five years compared to

only 3% of younger farmers. Likewise, older farmers were more likely to report difficulties around access to services including medical, public transport and Garda stations. The continued development of indicators within the Teagasc NFS to capture the multidimensional nature of farm sustainability is crucial. Full report available at: <https://www.teagasc.ie/publications/2017/small-farms-survey.php>.

### Acknowledgements

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# With cheese please

**TEAGASC** research into patterns of cheese consumption can help to dispel myths about the role of cheese in a healthy diet.



Cheese is an ancient food with archaeological evidence of its production dating back to 7,000 BC. More than nine millennia later, there are more than one thousand varieties of cheese available to choose from. Cheese is an excellent source of many essential nutrients such as calcium, phosphorous and protein, and can make a meaningful contribution to a healthy and balanced diet. However, in recent years cheese has received criticism primarily due to its salt and fat content.

A detailed analysis of cheese consumption and factors influencing its consumption in Irish adults was undertaken as part of the Food Institutional Research Measure (FIRM)-funded CheeseBoard research programme. The aim of this research was to examine cheese consumption in Irish adults and to determine its association with healthy eating, consumption of other foods and food choice attitudes. Analysis of food choice attitudes, sociodemographic information and consumption patterns was completed using the data from the National Adult Nutrition Survey (NANS – [www.iuna.net](http://www.iuna.net)).

Those consuming the recommended intake of 25g per day still remain within the dietary guidelines for fat intake in their overall diet.

## Findings

The findings illustrate varying cheese consumption patterns within the Irish population and outline what motivates Irish consumers to eat cheese. Approximately two-thirds of the population are

consuming cheese, with an average daily intake of 21g. In terms of overall fat intake, those who are consuming the recommended intake of 25g per day still remain within the dietary guidelines for fat intake from their overall diet.

Moreover, their fat intakes are the same as those who consume very little or no cheese at all. No association was found between cheese intake and body mass index (BMI). Indeed, there was no difference in BMI between those with the highest intake of cheese (40g/day) and those who did not consume cheese. Generally, non-consumers were slightly older.

This may reflect older adults' decisions to avoid foods associated with cholesterol and blood pressure, but it may also reflect the fact that younger people snack more, and frequently use cheese in these snacks.

Cheese consumers were also more likely to be consumers of bread, butter/spreads, soups, rice and pasta. This reflects more traditional use for cheese in lunches as a sandwich filling or served as an ingredient in the main meal of the day.

Food choice attitudes also varied, with different levels of cheese consumed across the population. Cheese consumption was low in consumers for whom food played an important role in the diet to de-stress or to feel good. Furthermore, lower cheese consumption was observed in those who self-reported good cooking skills, and had high portion size awareness and healthy eating intentions. In addition, consumers who assigned high levels of importance to sensory attributes such as taste and the appearance of food had lower cheese intakes. This indicates that cheese is not always the obvious choice for consumers in general who seek mood-enhancing, healthy or tasty foods. However, certain subgroups such as the cheese connoisseurs, who will actively seek out cheese as an indulgent and tasty product, are not accounted for in these analyses.

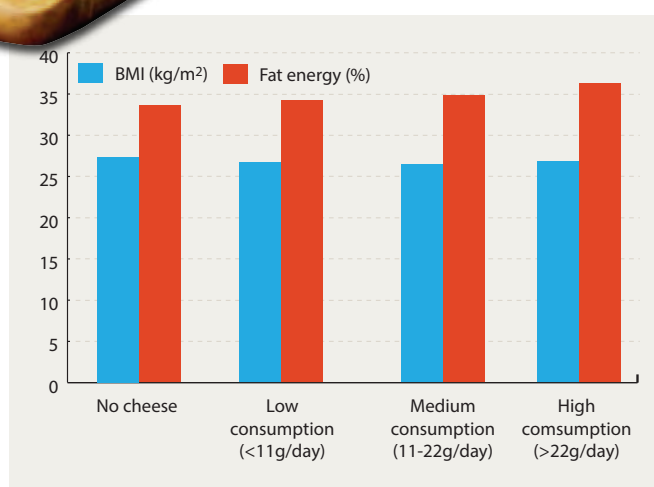


FIGURE 1: No association was found between cheese intake and BMI.

### Cheese – a healthy choice

These findings support the opportunity to clarify the role of cheese as part of a healthy diet, with clear and effective communication of the benefits of consuming the recommended portion of cheese and to dispel many health myths associated with its consumption. Cheese is frequently displaced from the diet in favour of other foods during weight loss or healthy eating regimes. Yet our evidence clearly shows that regular cheese consumers can remain within healthy eating guidelines for fat.

Furthermore, to remove it totally from the diet is to remove a valuable source of protein and many other essential nutrients, as well as the health-promoting bioactive compounds inherent in cheese. This can present a particular problem if these essential nutrients are not sufficiently delivered by the other foods in the

person's diet. Opportunities exist to communicate the role of cheese in a healthy diet where benefits are experienced without compromising on health.

Taste should not be overlooked as the most important food choice motive for most consumers and additional opportunities exist to promote the potential of cheese to offer a range of benefits that incorporates attributes such as taste, mood and health.

### Acknowledgements

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## APRIL 2018

April 4-6

Rennes, France

**CHEESE SYMPOSIUM 2018**

The 10th Cheese Symposium continues a tradition to showcase recent developments in both fundamental and applied research. It is organised by INRA in collaboration with Teagasc and UCC, and aims to cover a broad range of themes associated with ongoing cheese research and current market trends.

<https://symposium.inra.fr/cheese2018/>
Contact: [diarmuid.sheehan@teagasc.ie](mailto:diarmuid.sheehan@teagasc.ie)

April 9-11

Croke Park, Dublin

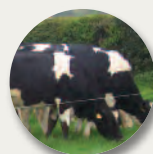
**BSAS ANNUAL CONFERENCE IN ASSOCIATION WITH THE AGRICULTURAL RESEARCH FORUM**

How can the livestock sector best use technology, research and innovation to meet the increasing global challenge of sustainable food production? Join the British Society of Animal Science (BSAS) and the Agricultural Research Forum (Teagasc) as they seek to address this question and more at the BSAS 2018 Annual Conference: 'Innovation to compete in the global livestock industry'. BSAS 2018 will see over 500 scientists, vets, policy-makers and farmers from across the world gather to hear about the challenges and opportunities facing the agri-food sector.

<https://bsas.org.uk/BSAS2018> Contact: [bsas@bsas.org.uk](mailto:bsas@bsas.org.uk) or [david.kenny@teagasc.ie](mailto:david.kenny@teagasc.ie)

April 23-27

Crowne Plaza Hotel, Dublin

**INTERNATIONAL DAIRY FEDERATION/ISO ANALYTICAL WEEK INCLUDING TEAGASC SATELLITE EVENT**

Hosted this year by Teagasc, this annual event is organised under the aegis of the IDF and ISO TC 34/SC 5 on milk and milk products. The week provides the facility for dairy laboratory managers, dairy scientists and analytical professionals to network

and exchange ideas on the latest developments in analytical solutions and the launching of new initiatives. On April 24, Teagasc will also hold a satellite event on 'Future Dairy Industry Laboratory Analytical Needs'. The objective of the symposium is to take stock of the evolving demands on dairy laboratories and analysts faced with ensuring product and process conformity to both local and international regulation, business to business (B2B) specifications and business to consumer (B2C) expectations.

[www.idfisodublin2018.com](http://www.idfisodublin2018.com)
Contact: [sheila.morgan@teagasc.ie](mailto:sheila.morgan@teagasc.ie)

April 24-25

Teagasc Ballyhaise College, Cavan, and Teagasc Moorepark, Cork

**PIG RESEARCH DISSEMINATION DAYS**

These two events will feature the broad array of research programmes currently ongoing in Teagasc's Pig Development Department. The events will provide attendees with the most up-to-date research results and the opportunity to meet with researchers.

[www.teagasc.ie](http://www.teagasc.ie)
Contact: [ciaran.carroll@teagasc.ie](mailto:ciaran.carroll@teagasc.ie)

## MAY

May 9

Teagasc Ashtown Conference Centre, Dublin

**E3S SYMPOSIUM – A TASTE OF CULTURE: UNDERSTANDING THE GLOBAL CONSUMER AND SENSORY PERCEPTION**

Sensory Food Network Ireland hosts the European Sensory Science Society (E3S) Annual Symposium. Speakers at the event include a number of high-profile international sensory science experts. There will also be a student competition, with excellent networking and collaboration opportunities. Registration is open via

[www.e3sensory.eu/](http://www.e3sensory.eu/) and [www.SensoryFoodNetworkIreland.ie](http://www.SensoryFoodNetworkIreland.ie)
Contact Eimear Gallagher or Sinéad McCarthy: [SensoryFoodNetworkIreland@teagasc.ie](mailto:SensoryFoodNetworkIreland@teagasc.ie)

## JUNE

June 12

Teagasc Ashtown Conference Centre, Dublin

**TEAGASC GATEWAYS – BEYOND BREXIT – MAKING FOOD INNOVATION GO FURTHER**

The Irish food industry faces a real challenge with the advent of Brexit. Like many Irish companies, those in the food sector export a sizeable proportion of their output to the UK and are exposed to uncertainty over regulations, customs and exchange rate volatility. As such, the role of research and innovation has never been more important. From new packaging technologies for a fresher product to value-added ingredients for new and emerging markets, the identification and adoption of new technologies are a crucial part of the Brexit response of food companies exposed to the UK market.

<http://bit.ly/BeyondBrexitTeagasc>
Contact: [tara.heffernan@teagasc.ie](mailto:tara.heffernan@teagasc.ie)

June 17-21

Rochestown Park Hotel, Douglas, Cork

**27TH EUROPEAN GRASSLAND FEDERATION GENERAL MEETING – SUSTAINABLE MEAT AND MILK PRODUCTION FROM GRASSLANDS**

Teagasc is hosting the 27th EGF. The scientific programme includes: resilient plants for grass-based ruminant production systems, adapting grassland systems to the dynamics of climate and resource availability; appropriate livestock for grasslands, key characteristics of animals adapted to and suitable for grasslands; environmental influences on grassland systems – consequences of climate change, mitigation strategies, and impacts on ecosystems; social and economic impacts of grass-based ruminant production; big data and smart technologies in grassland; and, knowledge transfer to stakeholders.

<http://www.egf2018.com/>
Contact: [EGF2018@abbey.ie](mailto:EGF2018@abbey.ie)

June 26

Teagasc Grange, Co. Meath

**BEEF 2018 TEAGASC BEEF NATIONAL OPEN DAY**

Under a theme of 'Enhancing Knowledge' this event aims to help beef farmers build on their abilities within their farming business. BEEF2018 is your opportunity to see first hand the results of Teagasc's comprehensive research and innovation programme and to meet Teagasc research and advisory staff. Villages include: Grassland, BETTER beef, dairy calf-to-beef, health and reproduction, feeding and meat quality, environment, education, and health and safety.

[www.teagasc.ie](http://www.teagasc.ie)
Contact: [edward.oriordan@teagasc.ie](mailto:edward.oriordan@teagasc.ie)

## AUGUST

August 30-31

Galway

**166TH EUROPEAN ASSOCIATION OF AGRICULTURAL ECONOMISTS SEMINAR**

This seminar is jointly hosted by Teagasc, NUI Galway and the FLINT Consortium. Sustainability has become one of the dominant themes for the development of the agricultural industry. In a development setting, sustainable agriculture is central to sustainable development goals. There are numerous dimensions to sustainability including measurement, economic, environmental and societal impact, behaviour and extension, value chains, marketing and policy levers. The EAAE Seminar on 'Sustainability in the Agri-Food Sector' will provide an opportunity to present and discuss progress in the analysis of sustainability in agriculture and extension approaches to incentivise farmers to adopt sustainable farm management practices.

<http://bit.ly/EAAE2018>
Contact: [Dilovar.Haydarov@teagasc.ie](mailto:Dilovar.Haydarov@teagasc.ie)For a full list of Teagasc food industry training events see: [www.teagasc.ie/food/food-industry-development](http://www.teagasc.ie/food/food-industry-development)For presentations from previous Teagasc events see: [www.teagasc.ie/publications](http://www.teagasc.ie/publications)