TEAGASC

RESEARCH IMPACT HIGHLIGHTS 2017

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Agriculture and Food Development Authority

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Teagasc
Agriculture and Food Development Authority

FOREWORD

The annual expenditure on research in Teagasc is approximately €65 million, which comes from a variety of sources. These include the core grant-in-aid funding allocated by the Government and competitive funding awarded nationally; principally, the Food Institutional Research Measure (FIRM), the Research Stimulus Fund and Competitive Forestry Research for Development (CoFoRD) programmes of the Department of Agriculture, Food and the Marine (DAFM). Important sources are Science Foundation Ireland, Enterprise Ireland, the Environmental Protection Agency, the Irish Research Council and international programmes such as EU Horizon 2020. Farmer levy contributions, industry-funded research, and earnings from services offered and farming activities also provide funding.

This is significant investment and given the Teagasc mission to support science-based innovation in the agri-food sector and the wider bioeconomy, it is very important to demonstrate the impact of this investment. In any given year, the impact of Teagasc research is a combination of the continuing impact of past research, and the new impact of recent research. This publication highlights some of these new impacts achieved in 2017.

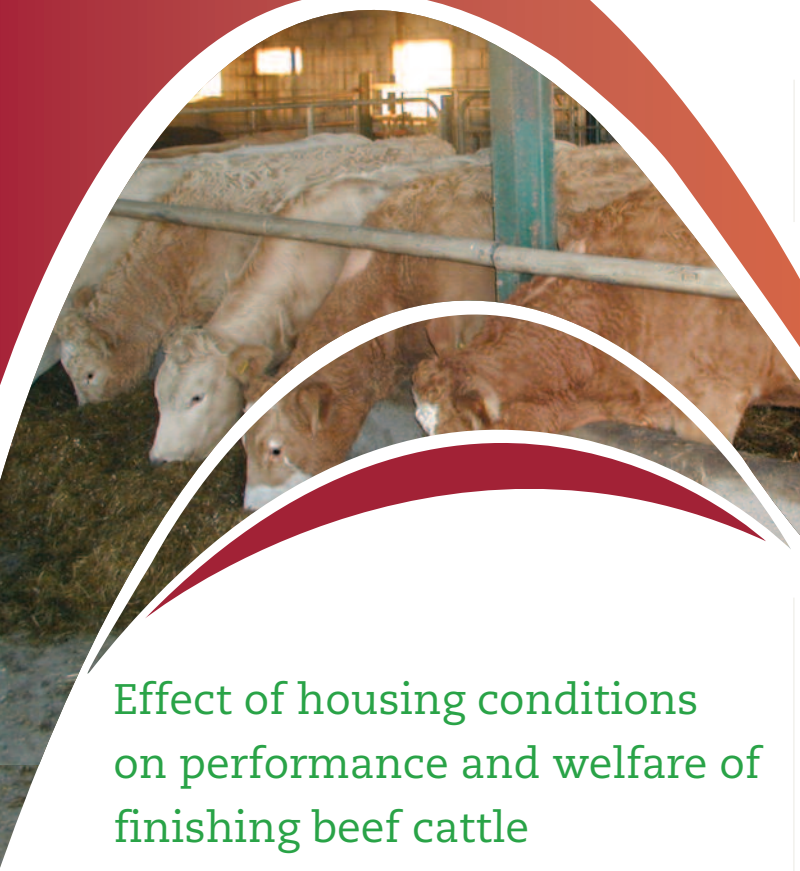
The examples selected are from across our programme and range from research conducted on issues in soils and the environment, animal production, crop production, food processing, food and health, to economics and social science. They are not an exhaustive account of the impact of Teagasc's research but they do demonstrate the breadth of research carried out by Teagasc. The impacts are made in a range of areas including livestock and crop (including horticulture) production, and the food industry, and they demonstrate an impact on shaping policy.

Of course researchers are not solely responsible for achieving these impacts. They also depend on the work of others, such as our advisers and specialists, experts in other organisations and industry, and farmers, food companies and policy makers, who ultimately make the changes in what they do based at least in part on our research.

I wish to commend my colleagues in Teagasc who carried out the research reported here or supported it in some way, and other researchers whose work did not make it into these 20 examples. I would also like to acknowledge the many collaborators we have in universities, institutes of technology and other external bodies, as well as the farming community and agri-food companies, which were directly involved in many of the research projects leading to these impacts. We greatly value those contributions, which are highlighted in the individual reports.

Finally, I would like to thank the funders of the research, which are listed above. I believe it is wise investment and will pay rich dividends across the agri-food industry, the wider economy and Irish society over the coming years.

Frank O'Mara
Director of Research, Teagasc



Effect of housing conditions on performance and welfare of finishing beef cattle

Bernadette Earley, Mark McGee, Edward O'Riordan, Michael Keane

Industry impact: In Ireland, concrete slatted floors are the predominant cattle housing system. Current recommendations for the minimum space allowance for beef cattle of various sizes in concrete slatted-floored pens is 2.0m^2 and 2.2m^2 for 500kg and 600kg animals, respectively. There are calls to increase this and to replace concrete slats with an alternative. Two experiments were performed. In experiment 1 bulls were accommodated on concrete slats with or without rubber mats. In experiment 2 heifers were accommodated on concrete slats with space allowances of 3.0, 4.5 and 6.0m^2 per head and straw at 6.0m^2 per head. Experiment 1 demonstrated that replacing concrete slats with rubber mats improved the average daily gain of bulls but had no effect on carcass weight. Dirt scores were not affected by floor type. Hoof lesions increased on rubber mats. Experiment 2 showed no difference in carcass weight at the different space allowances or on the straw treatment. Heifers housed on straw had longer lying times and greater dirt scores.
More generous space allowance to finishing cattle on concrete slats is not warranted, and rubber mats and straw as underfoot conditions did not enhance animal performance or welfare.

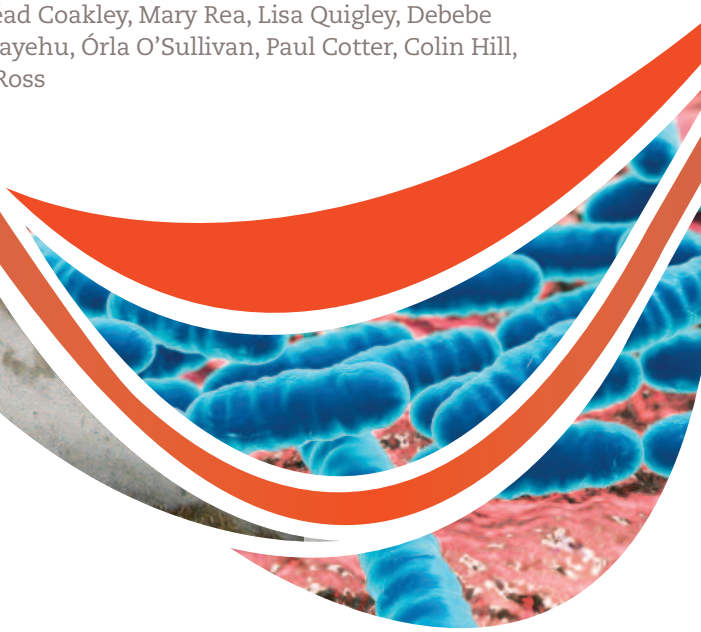
Contribution of non-research stakeholders: Knowledge transfer specialists and advisers have facilitated the dissemination of this research. Kepak allowed access to animals and facilities at Kepak, Co. Meath for experiment 2.

Other contributors and collaborators: Alan Kelly, UCD.

Funding: Teagasc grant-in-aid (RMIS 6675).

Lactobacilli as live bio-therapeutics for the treatment of *Clostridium difficile* infection

Mairéad Coakley, Mary Rea, Lisa Quigley, Debebe Alemayehu, Órla O'Sullivan, Paul Cotter, Colin Hill, Paul Ross



Industry impact: As antibiotic resistance increases globally, we are running out of effective antibiotics for the treatment of infections (WHO press release, 2017). Live bio-therapeutics offer a promising alternative for the treatment of infectious diseases, and may lead to reduced antibiotic use. *Clostridium difficile* infection (CDI) currently costs the Irish economy approximately €21 million annually. We screened the Teagasc and APC Microbiome Ireland culture collections for bacteria with anti-*C. difficile* activity. A *Lactobacillus gasseri* strain of human origin has been shown to reduce *C. difficile* shedding, and to have a positive impact on the gut microbiome in an animal model of CDI. This strain has been patented (EP16205994) and licensed to Alimentary Health Ltd, a leading Irish company in the live bio-therapeutics arena. This work won the 2017 Bridge Network Invention of the Year.

Other contributors and collaborators: APC Microbiome Ireland, University College Cork. National Irish Sequencing Centre, Teagasc. Sharon Sheahan, Technology Transfer Office, Teagasc. Pat Casey, School of Microbiology, University College Cork. Eileen Murphy and Barry Kiely, Alimentary Health Ltd.

Funding: Science Foundation Ireland.

Predicting the human capital requirements of Irish dairying

Paidi Kelly, Laurence Shalloo, Pat Dillon

Industry impact: Irish dairy farming has changed dramatically. In 2016, almost 50% of all dairy cows were milked in herds of 100 cows or more. Labour shortages are now flagged as a potential barrier to future expansion. A labour model was created which predicted the future human capital needs of the sector assuming cow numbers reach 1.6 million by 2025. Over 6,000 people will need to enter the sector over this time frame. Approximately 2,000 of these will be new employees working on larger-scale farms and 4,000 will be future farmers carrying on from those retiring. A national working group has been put in place by the Minister for Agriculture, Food and the Marine, Michael Creed TD, to develop a 'People in Dairy Action Plan'. This will lead to the development of a range of new initiatives that can help Irish dairying attract, develop and retain the people it needs for the future.

Contribution from non-research stakeholders: Stakeholder views were gathered from farm organisations, milk processors and other stakeholders as part of the research.

Funding: Dairy Research Ireland.

Decision-support packages for knowledge transfer

Áine Macken-Walsh

Industry impact: Transdisciplinary research findings in relation to the control of Johne's disease (JD) in dairy herds and grassland management were translated into practice-ready decision-support packages for farmers, advisers, vets and other rural professionals. Incorporating novel communication techniques, the JD control package is designed for interactive use on touchscreen/other electronic devices, and is also available in hard copy. Similarly, the grassland management transdisciplinary and open innovation process generated a complete methodology for advisers to facilitate a discussion group meeting on a host farm, identifying grassland management practices that are *cost-effective, impactful* and *achievable*. A physical resource pack was co-designed, containing all the tools facilitators require to implement the method.
Both packages incorporate storyboards, which are animated stories from real-life cases on Irish farms. The stories were selected to address key issues that are identified by sociological research as influencing farmer behaviour. They can be used in a variety of ways: to prompt discussion with/among farmers of sensitive or contentious issues; as scripts for role play; as publication features in print media; and, as social media posts. Over 20 Teagasc and dairy co-operative advisers are trained in the managing grass package, which has been practiced in over 30 discussion groups to date. The JD control package is used as a communications resource by dairy co-operatives and Animal Health Ireland.

Contribution from non-research stakeholders: Knowledge transfer specialists, advisers, farmers, the dairy co-operative sector and policy makers.

Other contributors and collaborators: School of Veterinary Medicine, UCD; Teagasc Animal & Grassland Research and Innovation Programme (AGRIP), Moorepark; Centre for Participatory Strategies, Ireland; Community Knowledge Initiative (CKI), NUI Galway.

Funding: Department of Agriculture, Food and the Marine (AgileTECH, 11/S/148; ICONMAP, 11/S/141) and Teagasc.

The productivity of Irish agriculture

Maria Martinez Cillero, Kevin Hanrahan, Michelle McCormack, Fiona Thorne

Industry impact: A newly established total factor productivity (TFP) index of Irish agriculture, using micro data from the Teagasc National Farm Survey (NFS) was completed during 2017. This index brings the branch of agricultural economics research in Ireland associated with productivity measurement and decomposition on a par with output in the UK, the US and Australia. Those countries have for a number of years tracked their productivity growth on an annual basis. The analysis of the productivity of Irish agriculture undertaken has identified that, relative to 2010, the TFP of Irish dairy farms has increased by 14% to the end of 2016. From a policy perspective, this research addresses the direction provided for in the recent policy reforms of the EU Common Agricultural Policy (CAP), which has placed increased emphasis on the importance of productivity measurement and monitoring.

Contribution from non-research stakeholders: Substantial stakeholder involvement contributed to the project via data assumptions and validation of estimated indicators for recent years.

Other contributors and collaborators: Lincoln University, NZ; Massey University, NZ; DairyNZ; Agriculture and Horticulture Development Board (AHDB), UK; OECD; INRA.

Funding: Department of Agriculture, Food and the Marine funding through the Research Stimulus Fund is gratefully acknowledged.

Accurate genetic evaluations for profitability in sheep

Nóirín McHugh, Alan Bohan, Áine O'Brien, Laurence Shalloo, Donagh Berry

Industry impact: The national sheep flock comprises 2.6 million breeding ewes and supports over 36,000 rural families. Key to sustainable genetic gain for the national sheep industry are accurate genetic evaluations on traits pertinent to Irish sheep production systems, each optimally weighted within a national breeding objective. Teagasc, in conjunction with Sheep Ireland, developed new mathematical and statistical approaches to differentiate genetically elite from inferior animals. Deterministic calculations revealed clear potential gains in profit through breeding. This, coupled with the calculation of economic value of each trait using the Teagasc lamb production bio-economic model, has enabled the updating of the national sheep breeding objectives across a range of production, maternal and health traits. The €uro-star breeding objectives are available to all Irish sheep producers for the selection of both terminal and replacement animals, and offer a more accurate selection tool for choosing animals for the next generation.

Other contributors and collaborators: Sheep Ireland.

Funding: Department of Agriculture, Food and the Marine Research Stimulus Funding.

Teagasc National Farm Survey: the sustainability of small farming in Ireland

Emma Dillon, Thia Hennessy, Brian Moran, John Lennon, John Lynch, Mary Brennan, Trevor Donnellan

Industry impact: A special survey of small farms conducted through the Teagasc National Farm Survey highlighted that half of all small farms (those with an agricultural output of <€8,000) are in an economically vulnerable position. Despite the low levels of production on these farms (of which there are over 52,000) they account for 37% of farms nationally and are primarily located in the border and western regions. In addition to the economic and environmental situation on these farms, the survey garnered information on the future farming intentions of respondents, as well as sentiment on rural isolation and security. The data has also helped to inform related work which is ongoing in the area of social sustainability measurement. The report was launched at a stakeholder conference on rural viability in Teagasc Ashtown, Dublin, where it prompted much discussion among policy makers and representatives from farm organisations and rural development agencies.

The research gained much media attention, resulting in a number of press articles and radio interviews. Two articles have been published in *TResearch* (Teagasc's research and innovation magazine) and the findings are currently being written up for peer review publication. See the full report at: www.teagasc.ie/publications/2017/small-farms-survey.php.

Other contributors and collaborators: University College Cork.

Funding: Teagasc grant-in-aid funding.

Submission for third review of the Nitrates Directive National Action Programme

Teagasc Water Framework Directive (WFD) Working Group. Ger Shortle, David Wall, Pat Murphy (editors)

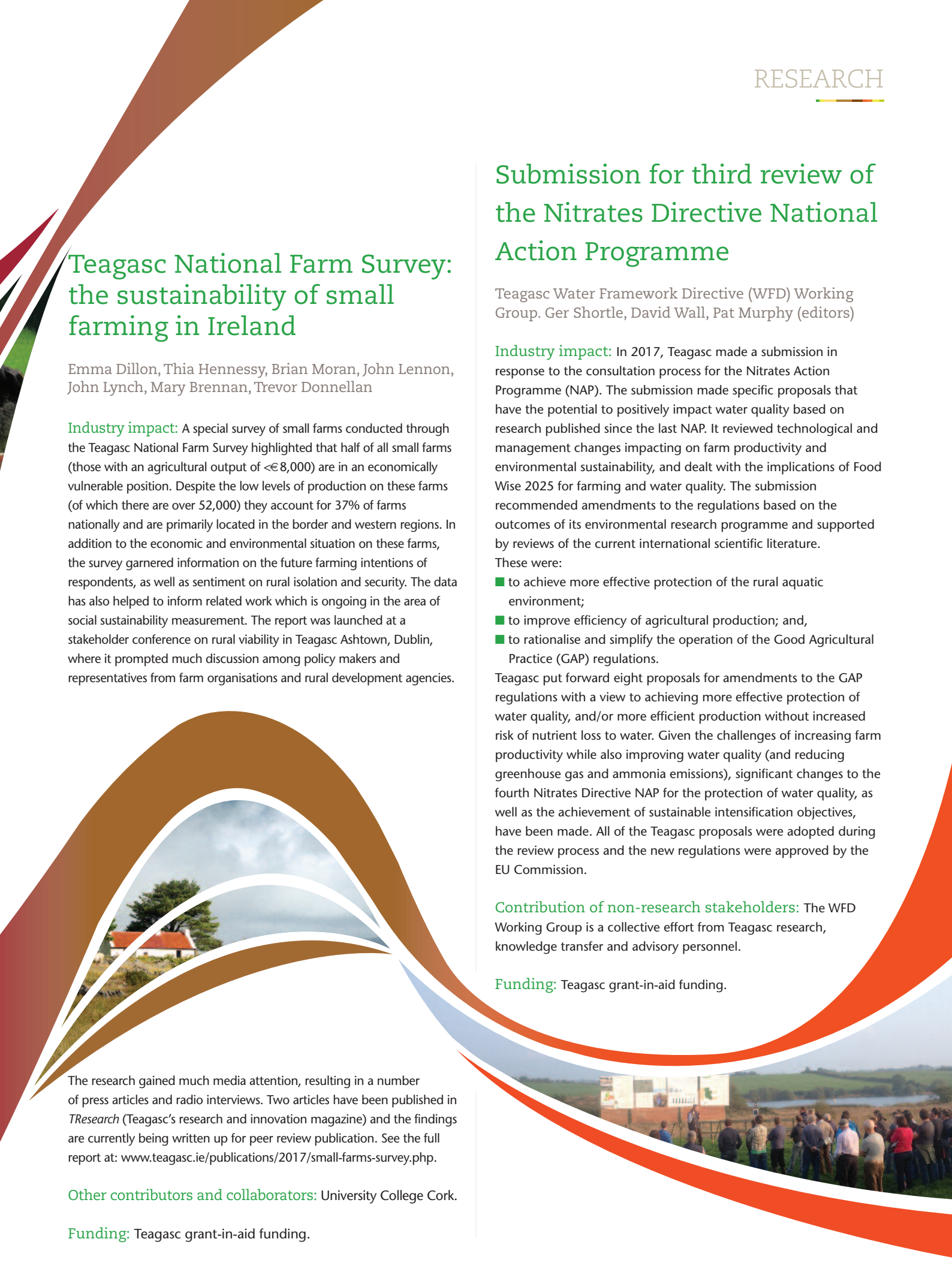
Industry impact: In 2017, Teagasc made a submission in response to the consultation process for the Nitrates Action Programme (NAP). The submission made specific proposals that have the potential to positively impact water quality based on research published since the last NAP. It reviewed technological and management changes impacting on farm productivity and environmental sustainability, and dealt with the implications of Food Wise 2025 for farming and water quality. The submission recommended amendments to the regulations based on the outcomes of its environmental research programme and supported by reviews of the current international scientific literature. These were:

- to achieve more effective protection of the rural aquatic environment;
- to improve efficiency of agricultural production; and,
- to rationalise and simplify the operation of the Good Agricultural Practice (GAP) regulations.

Teagasc put forward eight proposals for amendments to the GAP regulations with a view to achieving more effective protection of water quality, and/or more efficient production without increased risk of nutrient loss to water. Given the challenges of increasing farm productivity while also improving water quality (and reducing greenhouse gas and ammonia emissions), significant changes to the fourth Nitrates Directive NAP for the protection of water quality, as well as the achievement of sustainable intensification objectives, have been made. All of the Teagasc proposals were adopted during the review process and the new regulations were approved by the EU Commission.

Contribution of non-research stakeholders: The WFD Working Group is a collective effort from Teagasc research, knowledge transfer and advisory personnel.

Funding: Teagasc grant-in-aid funding.



New sensory panels for characterising flavour and texture profiles of food

Emily Crofton, Carol Griffin, Carmel Farrell, Eimear Gallagher

Industry impact: Descriptive sensory techniques can assist companies to design and formulate food products by understanding how ingredients and processing impact the sensory profiles of foods. Teagasc, in conjunction with Sensory Food Network Ireland and Meat Technology Ireland, have screened and extensively trained three external descriptive sensory panels to characterise and unravel the complex flavour and texture profiles of food, with a particular focus on meat. These expert panels are a new resource for the food industry, and they are now being utilised for a wide range of applications including product development, quality control and shelf-life evaluation. These panels are also an important tool in Teagasc's current sensory research programme, participating in studies of cross-cultural sensory perception. Sensory evaluation is conducted in our state-of-the-art sensory science suite at Ashtown, which is equipped with 18 individual computerised sensory testing booths and specialised cooking equipment. All booths are equipped with adjustable lighting (white, red and green) and temperature-controlled ventilation, together with the latest sensory data collection software, Compusense Cloud.

Contribution of non-research stakeholders: Industry-led sensory projects.

Other contributors and collaborators: Teagasc co-ordinates Sensory Food Network Ireland, which comprises 10 national research institutions including AFBI, UCD, UCC, DIT, CAFRE, GMIT, LIT, Ulster University and St Angela's College, Sligo.

Funding: Department of Agriculture, Food and the Marine (Sensory Food Network Ireland) and Meat Technology Ireland.

Making dairy farms more energy efficient

Tom O'Dwyer, Barry Caslin, John Upton

Industry impact: Teagasc and the Sustainable Energy Authority of Ireland (SEAI) collaborated to deliver a project entitled Energy Efficiency on Dairy Farms. The pilot scheme was designed around research carried out by Teagasc, led by researcher John Upton, which showed how variable speed drive (VSD) pumps can dramatically reduce the electricity usage during the milking process. The current project funded the installation of high-efficiency VSD vacuum pumps, VSD milk pumps and smart meters. In total, the SEAI received 78 applications from dairy farmers for grant funding. Some 51 dairy farmers progressed to install the equipment (65%), of which 43 were Teagasc clients (84%). In total, the SEAI provided funding of €188,000 (38% of the total investment of €487,000). With the 51 participating farmers having an average herd size of 184 cows, electricity savings of up to €800 per year are possible. The funding scheme is to be run again in 2018.

Contribution of non-research stakeholders: The project was delivered with the support of Teagasc knowledge transfer advisers, who used their network of clients to identify dairy farmers suitable to avail of the grant aid, and to assist dairy farmers in completing the application process. The VSD pump suppliers were also involved.

Other contributors and collaborators: The SEAI was the other major non-Teagasc collaborator on this project.

Funding: Funding was provided by the SEAI.

Cobweb-free mushrooms

Helen Grogan, Donal Gernon, Patrick Sedeyn, Nancy Pyck

Industry impact: Cobweb disease is a troublesome pathogen of cultivated mushrooms. A recently completed EU project, MushTV, co-ordinated by Teagasc, sought to identify potential new biological or chemical products to control this and other mushroom diseases. Metrafenone, a relatively new fungicidal active ingredient (used to control powdery mildew in grapes), was evaluated and shown to be very effective. The MushTV results facilitated getting metrafenone approved for cobweb control across Europe. Donal Gernon, Teagasc Specialist Mushroom Adviser, says that since the introduction of this product in Ireland in 2016, disease levels have dropped. There is a significant economic upside for producers as disease reduction is immediately visible on the bottom line. Once under control, good crop management and hygiene are then used to keep it in hand.

Contribution of non-research stakeholders: The mushroom industry across Europe participated in seminars to obtain information on this new product and to learn how to incorporate its use into their integrated pest management (IPM) procedures. Data was provided to BASF to facilitate registration.

Other contributors and collaborators: MushTV was a consortium of 17 mushroom businesses, mushroom grower organisations and research organisations across Europe. The trial work was done at Inagro, Belgium.

Funding: EU FP7-SME-2011-286836.* Provincial Government of West Flanders. Teagasc core funding.
*The views expressed reflect the authors' views. The EU is not liable for any use that may be made of the information.

Milkybiotics – new bioactivity for bovine colostrum

Sinead T. Morrin, Jonathan A. Lane, Mariarosaria Marotta, Rita M. Hickey

Industry impact: It is now widely accepted that the bacteria present in our gut have a large impact on our overall health. What we eat can influence the type of bacteria found in our gut. Teagasc has begun to explore how diet may lead to the establishment of larger numbers of bacteria with health-promoting properties in the gut. Milk, either in the form of breast milk or cow's milk formula, is among the first foods introduced in our diet. As such, the effect of colostrum from cows (the milk produced in the first days after birth) and how it might condition the intestinal cell surface allowing health-promoting bacteria to attach to the gut cells in greater numbers was assessed. After intestinal cells were exposed to colostrum components, the attachment of a range of health-promoting bacteria to the cells was dramatically improved. The impact of colostrum components on the intestinal cell genome, proteome and glycome were investigated. Overall, the colostrum fraction altered the cell surface sugar pattern of intestinal cells and the research provides an insight into how these bacteria colonise the human gut. Such findings are of great importance to individuals with lower counts of these bacteria, such as formula-fed infants, the elderly and those on antibiotic treatment. A patent has been filed and discussions are ongoing with interested companies.

Other contributors and collaborators: Lars Bode, Department of Pediatrics and Larsson-Rosenquist Foundation Mother-Milk-Infant Center of Research Excellence, University of California, San Diego.
Stephen Carrington and Jane A. Irwin, Veterinary Sciences Centre, School of Veterinary Medicine, University College Dublin.
Lokesh Joshi, Advanced Glycoscience Research Cluster, National Centre for Biomedical Engineering Science, National University of Ireland Galway.

Funding: Teagasc.

Healthy diet, healthy climate

Sinéad McCarthy, John Hyland, Maeve Henchion

Industry impact: The dietary-related greenhouse gas emissions of the Irish population were calculated by combining existing information on the emission profile of individual foods with food consumption data from the National Adult Nutrition Survey. Consumers were grouped into three patterns of food consumption and resultant greenhouse gas (GHG) emissions and dietary behaviours were profiled. The culturally sustainable group had healthy dietary behaviours, consumed the most red meat and yet had the lowest level of food-related GHG emissions compared to the other two groups. Hence, recommendations to reduce red meat consumption may not result in lower emissions. Strategies that focus on the reduction of carbon footprint at the food production stage may have more climatic benefit than trying to change consumer food consumption behaviour. This research has been of particular relevance to Meat Technology Ireland, Meat Industry Ireland, as well as supporting Bord Bia's Origin Green sustainability programme.

Publications arising from this research: Hyland, J.J., Henchion, M., McCarthy, M. and McCarthy, S.N. (2017). 'The climatic impact of food consumption in a representative sample of Irish adults and implications for food and nutrition policy'. *Public Health Nutrition*, 20 (4): 726-738.
Hyland, J.J., McCarthy, M.B., Henchion, M. and McCarthy, S.N. (2017). 'Dietary emissions patterns and their effect on the overall climatic impact of food consumption'. *International Journal of Food Science & Technology*, 52 (12): 2,505-2,512.
Hyland, J.J., Henchion, M., McCarthy, M. and McCarthy, S.N. (2017). 'The role of meat in strategies to achieve a sustainable diet lower in greenhouse gas emissions: A review'. *Meat Science*, 132: 189-195.

Other contributors and collaborators: Mary McCarthy, UCC.

Funding: Department of Agriculture, Food and the Marine (ReVisData 13/F/527).

Reducing antibiotic usage on pig farms in Ireland

Ciarán Carroll, Edgar Garcia Manzanilla

Industry impact: Teagasc, in collaboration with the Department of Agriculture, Food and the Marine (DAFM), pig veterinary practitioners (PVPs) and farmers, started using the biosecurity assessment programme BIOCHECK.UGent in 2016 and completed its implementation on more than 70 farms in 2017. The use of this tool results in significant improvements in husbandry practices, increases profits and reduces the use of antibiotics in pig farms. The first farmer using the programme in Ireland has been nominated EU Ambassador for Biosecurity 2017 within the EU PiG Horizon 2020 thematic network.
This is a Europe-wide network developed to promote good practice in the pig industry and is made up of a consortium of 19 organisations from 13 EU member states (see: www.eupig.eu/). It is expected that the use of this tool will result in further improvement in coming years.

Contribution of non-research stakeholders:
A collaborative approach was taken involving Teagasc researchers, Teagasc pig development officers (knowledge transfer), farmers, their PVPs and the DAFM.

Other contributors and collaborators: Jeroen Dewulf, Merel Postma (University of Ghent), Nola Leonard (UCD School of Veterinary Medicine).

Funding: DAFM project PathSurvPigs 14/S/832, Teagasc project FeedStrats ref. 6666, and the EU PiG project, a Horizon 2020 thematic network (RUR-10-2016-2017).

Grass weed control in Irish arable crops

Ronan Byrne, John Spink, Tim O'Donovan, Susanne Barth

Industry impact: Grass weed control in cereal crops has become one of the greatest challenges to agriculture, causing higher losses and costing more to tackle than crop pests or diseases. In Ireland, sterile brome (*Bromus sterilis*), wild oats (*Avena fatua*), canary grass and black-grass (*Alopecurus myosuroides*) have become increasingly problematic.
We mapped the prevalence of emerging grass weeds, investigated their herbicide resistance status, and collected management information from surveyed fields. We discovered rising levels of herbicide resistance in these four grass weeds on Irish farms. This research has resulted in an awareness among growers of herbicide-resistant weeds, which has led to farmers altering management practices in response to weed control failures.

Contribution from non-research stakeholders: Teagasc advisers, especially Ciaran Collins, Shay Phelan, Michael Hennessy and the Irish seed trade.

Other contributors and collaborators: Paul Neve, Rothamsted Research, Rob Freckleton, University of Sheffield, Sarah Cook, ADAS.

Funding: This project is receiving funding in part from the Irish Seed Trade Association (ISTA).

Mining the metabolic diversity of microbes for flavour diversification in dairy products

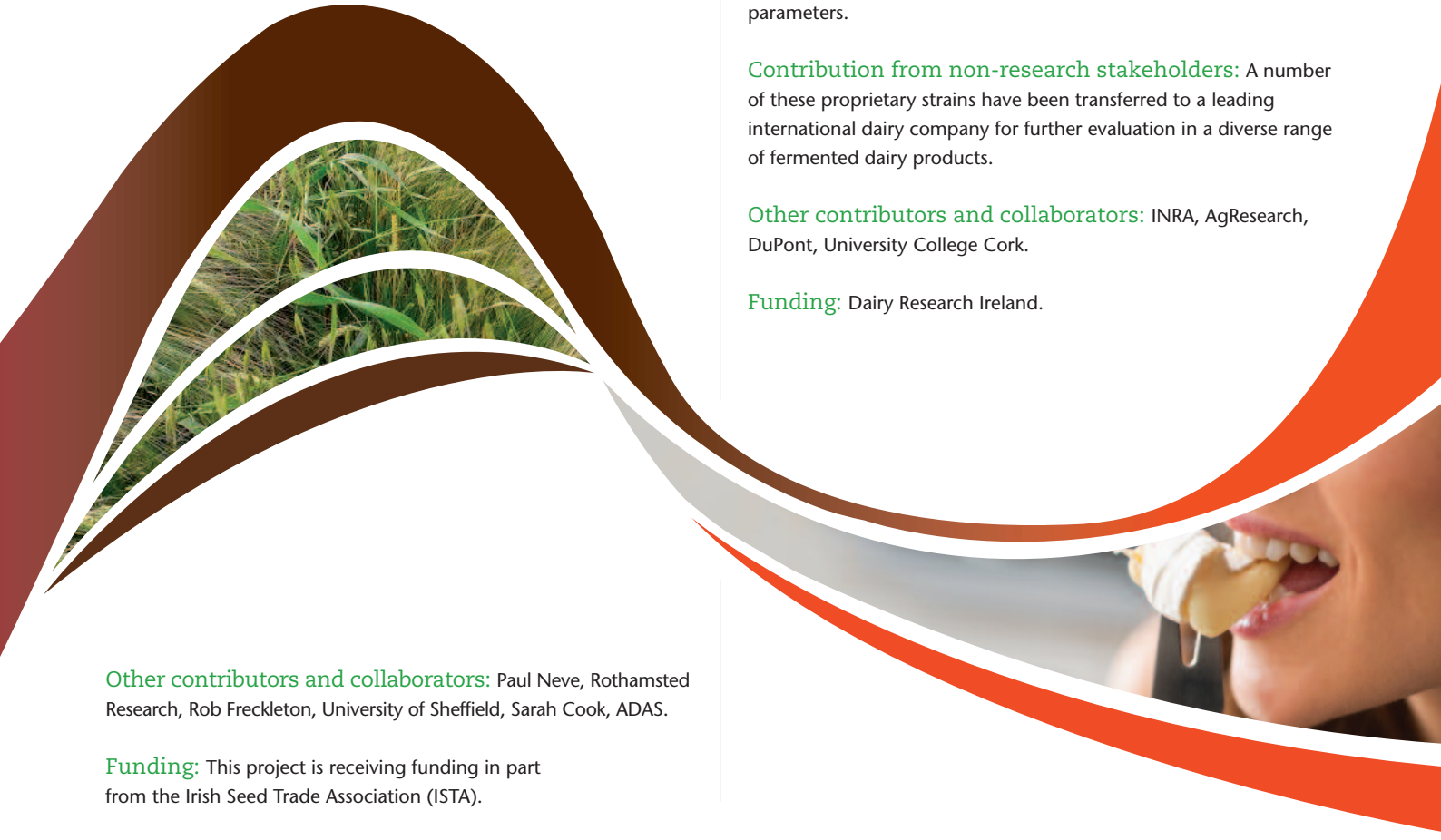
Olivia McAuliffe, Daniel Cavanagh, Kieran Kilcawley

Industry impact: The identification of specific bacterial strains with the capability of influencing flavour development in dairy products is one route to product diversification in the fermented dairy sector. An in-depth knowledge of the metabolic potential of these strains and the key technological properties that make their application in the dairy industry possible can allow starter blends to be tailor-made to suit industry needs. *Lactococcus lactis* is an organism used in the production of fermented dairy products such as hard and semi-hard cheeses. Normally associated with the dairy environment, the origin of this species is the plant niche. Strains of *Lactococcus lactis* from non-dairy niches were found to be far more metabolically diverse than their dairy counterparts. This metabolic potential was reflected in their increased enzyme activities, which could be harnessed to improve the organoleptic properties of dairy products. Non-dairy strains of *Lactococcus lactis* isolated from grass were shown to diversify flavour in Gouda cheese. These cultures are a potential resource for companies interested in expansion of their product portfolio without large-scale changes to manufacturing parameters.

Contribution from non-research stakeholders: A number of these proprietary strains have been transferred to a leading international dairy company for further evaluation in a diverse range of fermented dairy products.

Other contributors and collaborators: INRA, AgResearch, DuPont, University College Cork.

Funding: Dairy Research Ireland.



Bioeconomy impact

Maeve Henchion, Laura Devaney

Industry impact: Policy impact currently rather than industry impact; industry impact will be further down the line in terms of new opportunities through new value chains. Research conducted within the Department of Agriculture, Food and the Marine (DAFM)-funded research project BioÉire, supported by the Teagasc Bioeconomy Working Group, directly contributed to the National Policy Statement on the Bioeconomy. Specifically, BioÉire identified and assessed national bio-based feedstocks, assessed market opportunities and challenges, identified and prioritised new value chains and outlined the necessary framework conditions for success. Results from BioÉire were presented to the Government Inter-Departmental Group, which was established to develop the National Bioeconomy Policy Statement as required in the National Rural Development Action Plan and the Action Plan for Jobs. Furthermore, Teagasc co-hosted, with the Department of the Taoiseach, a consultative stakeholder event which was framed around the BioÉire results. This led to the preparation of a discussion document by the Department of the Taoiseach and was the basis on which the Department invited public submissions. Teagasc made a direct submission in response to this invitation and also provided input to the DAFM's submission. BioÉire is specifically mentioned in the resulting National Policy Statement, with reference to future opportunities worthy of further investigation. The National Policy statement is available at: www.taoiseach.gov.ie/eng/News/Government_Press_Releases/Bioeconomy.pdf. Further information on BioÉire is available at: www.teagasc.ie/publications/2017/bioeire-results-launch.php.

Contribution of non-research stakeholders: Teagasc Bioeconomy Working Group.

Other contributors and collaborators: Kevin McDonnell and Eilín Walsh (UCD), Paul O'Reilly (DIT), Bart Bonsall and James Gaffey (tcbb Resource), Padraic Ó hUiginn (tcbb Resource and Ryan Institute, NUIG).

Funding: Department of Agriculture, Food and the Marine.

Assessing the impact of a GM potato engineered for late blight resistance

Ewen Mullins

Industry impact: As part of the EU-funded Assessing and Monitoring the Impacts of Genetically-modified plants on Agro-ecosystems (AMIGA) project, Teagasc completed field evaluations of a potato that was genetically engineered for resistance to late blight disease. Under current conventional management, potato growers typically require greater than 12 fungicide sprays per season to ensure the economic viability of their potato crops. The engineered potato (developed by Wageningen University, Netherlands) displayed robust resistance to late blight disease through three successive seasons of field trials at Oak Park. Most significantly, an environmental assessment of the study indicated that there was no significant difference between the GM variety and its non-GM comparator variety. Using the internationally recognised and publicly available Environmental Yardstick for Pesticides to quantify the environmental impact of chemical crop protection on water life, soil life and groundwater, the cultivation of a conventional variety under current practice scored over 700 environmental impact points. In contrast, the cisgenic-resistant variety scored less than ten points.

Contribution of non-research stakeholders: Over 80 knowledge transfer events were completed with stakeholders, farmers, industry, policy makers and consumer groups over three years.

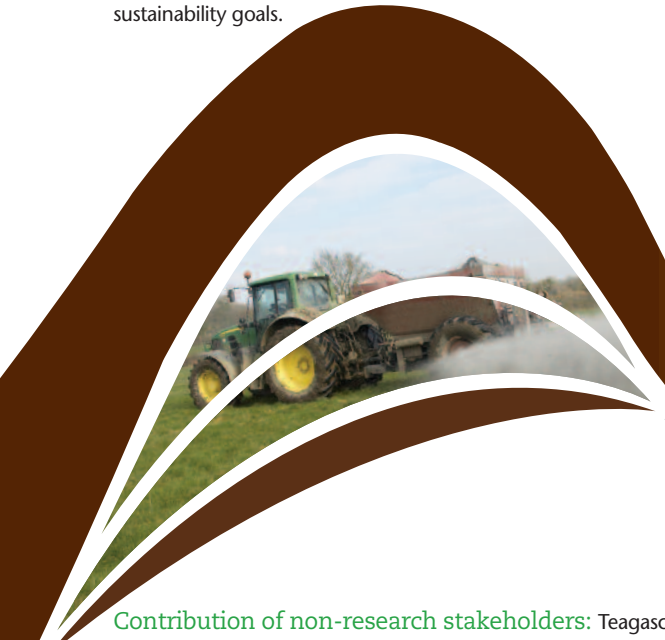
Other contributors and collaborators: The AMIGA project had 22 partners, with the majority of work at Oak Park completed in collaboration with Wageningen University.

Funding: EU Framework Programme 7.

Nutrient Efficiency Working Group – lime campaign 2013-2017

David Wall, Mark Plunkett

Industry impact: Over the 2012-2014 period only 37% of soil samples in the soil fertility database (110,523 samples) had optimal soil pH levels (>6.2). A lime campaign was initiated in late 2013 with regional farmer and industry workshops held at Teagasc farmer training colleges. Over the subsequent four years, research-supported knowledge on the importance of lime has been disseminated widely to the agricultural industry at the national soil fertility conferences, national open days, advisory and industry training events, farmer discussion groups and through a series of technical bulletins, advisory leaflets and social media videos. Through the concerted efforts of Teagasc research and advisory, in conjunction with lime and fertiliser industry groups, this lime campaign has led to a rapidly improving trend in soil pH levels nationally, with 45% of soil samples currently having optimal soil pH (109,894 samples). The campaign has promoted good nutrient management practice across Irish farms, helped to underpin the Government's Food Wise 2025 strategy for agricultural growth, while simultaneously helping farmers to achieve their profitability and environmental sustainability goals.



Contribution of non-research stakeholders: Teagasc knowledge transfer and advisory, which disseminated the benefits of the lime application message to farmers and the agri-industry.
The Fertiliser Association of Ireland, which published Technical Bulletin No 2: 'Soil pH and Lime'.
The Ground Limestone Association of Ireland. Grolime promoted the use of lime across different media.

Funding: Teagasc grant-in-aid funding.

Specialised meat products target promotion of healthy ageing

Ruth Hamill, Cristina Botinestean, Sephora Baugreet, Maurice O'Sullivan, Paula Conroy, Sinéad McCarthy, Terence Hagan, Joe Kerry

Industry impact: Older people need to consume more high-quality protein than younger cohorts to help counteract the steep decline in muscle mass that occurs as we age. However, many challenges accompany the ageing process such as decline in sensory acuity, difficulties with chewing and swallowing, and reduced appetite, all of which limit food intake in this cohort. The Meat4Vitality project developed targeted meat products for the growing cohort of over 65s. Red meat is an ideal foodstuff to support healthy ageing, containing the essential amino acids in the right proportions to promote muscle maintenance, as well as key micronutrients, and it also provides an excellent food vehicle for fortification with health-promoting ingredients. Aiming to promote healthy ageing, the researchers developed novel steaks with a softer texture from economical cuts, highly flavoured comminuted products to address chemosensory decline, and protein-enriched beef patties and restructured steaks to deliver approximately 30g of protein in a small portion size (75g), as favoured by older people. Acceptability of many novel products to the target market was demonstrated using consumer panels of over-65s in UCC and the Agri-Food and Biosciences Institute (AFBI) and these panels also showed that within the over-65 cohort, sensory acuity was stratified with age.

Contribution from non-research stakeholders: The project advisory board included major processors, Meat Industry Ireland and UCD dietician, Clare Corish, who provided guidance on product formulation to optimally address healthy ageing.

Other contributors and collaborators: University College Cork, Agri-Food Biosciences Institute.

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Impact of Teagasc research publications

Máire Caffrey

Research-performing organisations, such as Teagasc, need to evaluate their research output to justify investment, guide decisions on the direction of future research and understand how their performance compares to similar organisations. Funding bodies require data to show return on investment and researchers like to know how their peers rate their outputs. Teagasc is monitoring its research impact and compiling that data for stakeholders.

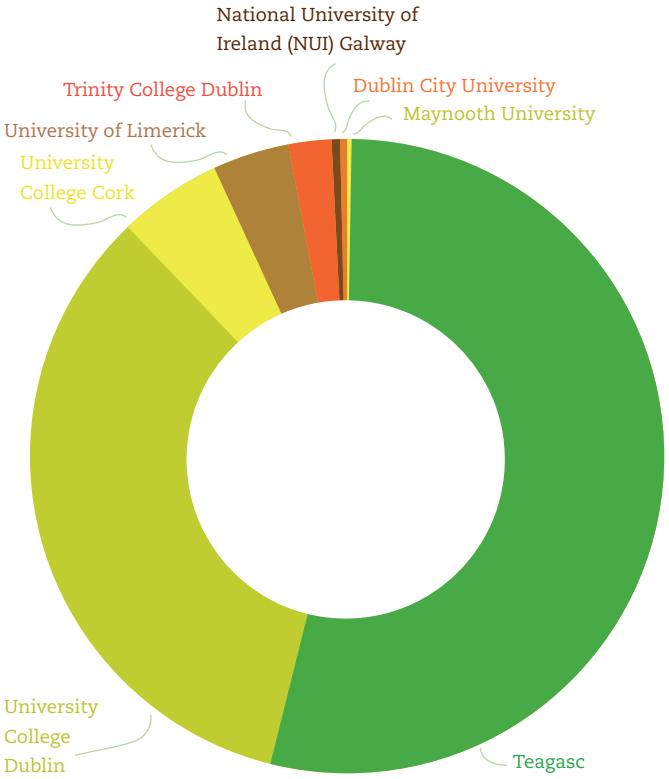

Figure 1. *Number of papers by Teagasc and Irish universities that are indexed in the Web of Science category Agriculture, Dairy and Animal Sciences (2013-2017).*

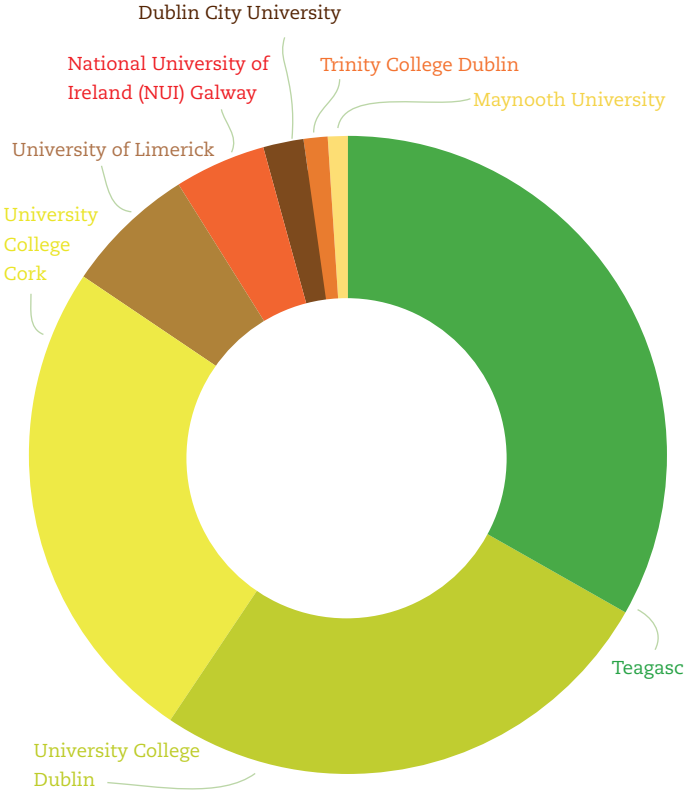

Figure 2. *Number of papers by Teagasc and Irish universities that are indexed in the Web of Science category Food Science and Technology (2013-2017).*

Citation of a researcher's articles is one measure of the impact of their research. A citation count provides the basis for bibliometric analysis. There are a number of resources available providing both citation counts and other metrics. One such resource used by Teagasc is the Web of Science, and its accompanying research evaluation tool InCites. Web of Science is an online subscription-based citation indexing service, which enables in-depth exploration of the scientific literature. It also provides a count of citations to each article it indexes. InCites is a research evaluation tool that allows an organisation to analyse institutional productivity and benchmark output against peers worldwide.

It is important to understand how our performance ranks against other research bodies. Comparisons within (subject) categories are the most meaningful. To place our performance in a national context, we can compare Teagasc's performance with that of the Irish universities, within two relevant subject categories: (a) Agriculture, Dairy and Animal Sciences; and, (b) Food Science and Technology.

Considering articles published in the period 2013 to 2017 in category (a), Teagasc ranks first by number of publications (329) and also by number of citations. For the same period in category (b), Teagasc ranks number one by number of publications (687) and second by number of citations.

Of course, all bibliometric analysis must be placed in context and the impact of our research must be evaluated in other ways, to give an overall assessment.

Research Programmes

Teagasc's mission is to support science-based innovation in the agri-food sector and wider bio-economy that will underpin profitability, competitiveness and sustainability.

This is achieved through the close coupling of research and knowledge transfer in four programme areas:

- Animal & Grassland Research and Innovation;
- Crops, Environment and Land Use;
- Food; and,
- Rural Economy and Development.

Each of these programmes is composed of research, development and knowledge transfer/industry development departments, as outlined below. Research is conducted at six dedicated locations, while knowledge transfer professionals are located throughout the country (see map on back cover).

Our annual research portfolio comprises some 350 research projects, carried out by 800 scientific, technical and other support staff and Walsh Fellow graduate students in our research centres throughout Ireland.

In order to maximise the impact of our research, Teagasc actively collaborates with research organisations across the world. This collaboration stretches from individual projects and publications right up to formal alliances and partnerships.

Animal & Grassland Research and Innovation Programme Departments

- Animal & Bioscience Research
- Grassland Science Research
- Livestock Systems Research
- Pig Development
- Dairy Knowledge Transfer
- Drystock Knowledge Transfer

Locations:

- Athenry, Co Galway
- Grange, Dunsany, Co Meath
- Moorepark, Fermoy, Co Cork

Crops Environment and Land Use Programme Departments

- Crops Research
- Environment, Soils and Land Use Research
- Forestry Development
- Horticulture Development
- Agricultural Catchments
- Crops Knowledge Transfer
- Environment Knowledge Transfer

Locations:

- Johnstown Castle, Co Wexford
- Oak Park, Co Carlow
- Ashtown, Dublin 15

Food Programme Departments

- Food Biosciences Research
- Food Safety Research
- Food Chemistry & Technology Research
- Food Industry Development
- Food Quality & Sensory Science Research

Locations:

- Ashtown, Dublin 15
- Moorepark, Fermoy, Co Cork

Rural Economy and Development Programme Departments

- Agricultural Economics and Farm Surveys Research
- Spatial Analysis, Food Marketing and Agri-Innovation Research
- Farm Management and Rural Development
- Knowledge Transfer

Locations:

- Ashtown, Dublin 15
- Athenry, Co Galway

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