

RESEARCH AND
INNOVATION NEWS
AT TEAGASC
www.teagasc.ie

Research

Volume 12: Number 4. Winter 2017

Visionary research
IMAGES THAT BRING RESEARCH TO LIFE

FESTIVAL OF FARMING AND FOOD

CHEESE QUALITY

HEALTH AND TASTE

CONTENTS

Cover image, taken by Brian McGuinness, shows the fungus *Cylindrocladium buxicola* stained and viewed on a light microscope with dark field filter.



Be social! Connect with Teagasc



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

www.teagasc.ie

© Articles and images cannot be reproduced without the prior written consent of the Editor. Please note images may have been obtained from an independent source. Please quote *TResearch* when using direct quotes from articles.

EDITOR

Catriona Boyle 076 111 1219
catriona.boyle@teagasc.ie

ADMINISTRATOR

Ann Kane
ann.kane@teagasc.ie

EDITORIAL STEERING GROUP

Catriona Boyle	Stephen Butler	Michael Diskin
Eric Donald	Niall Farrelly	Helen Grogan
Tim Guinee	Richard Hackett	Ann-Marie Hardiman
Anne Kinsella	Gary Lanigan	Sinéad McCarthy
Paul O'Grady	Edward O'Riordan	Brijesh Tiwari
Declan Troy	Miriam Walsh	

Editorial 3

News 4

Teagasc researchers make World Most Highly Cited List
FutureMilk
Food innovation hub

Features

Festival of Farming and Food	8
Stepping on the gas – FACCE ERA-GAS ERA-NET Cofund	10
Vision of Research and Innovation	12
Rising stars – FOODstars project	14
Energy debate heats up	16

Animal and Grassland Research and Innovation (AGRI)

Purple patch	18
Dried, sealed, delivered	20
Piggy in the middle	22
Beefing up the suckler herd	24

Crops, Environment and Land Use (CELU)

Shedding light on mushroom viruses	26
Nitrous oxide from ruminant excreta	28
Thinning for profit	30

Food

Improving meat fatty acid profile	32
Membrane filtration for consistent cheese	34

Rural Economy and Development (RED)

The status quo on small farms	36
The sweet spot for health and taste	38

Events 40

Reference to any commercial product or service is made with the understanding that no discrimination is intended and no endorsement by Teagasc is implied.



TResearch Teagasc,
Oak Park, Carlow, R93 XE12

Published on behalf of Teagasc by

Th!nkMedia

The Malthouse, 537 NCR,
Dublin 1, D01 V822.

T: 01 856 1166 E: ann-marie@thinkmedia.ie www.thinkmedia.ie

Design: Tony Byrne, Tom Cullen and Eimear Moroney

Editorial: Ann-Marie Hardiman, Paul O'Grady and Colm Quinn

Strategic management of research organisations

More than 90 delegates from 21 countries attended this year's EURAGRI conference recently held in Teagasc Ashtown, which dealt with the business of doing research in Europe's public research and development organisations, with a particular focus on their strategic management challenges. Delegates considered those challenges within the context of the changing role and expectations of agricultural research: the new partnerships and stakeholders needed to deliver; the structures and tools required in addressing new research questions; and the requirement for more extensive reporting and evaluation.

Agriculture faces significant new challenges in the coming decades. It must produce more high-quality and safe food for a growing, increasingly affluent, global population, while vying for access to increasingly scarce natural resources, preserving biodiversity and water quality, restoring fragile ecosystems, and mitigating the effects of climate change. It must also adapt to new plant and animal disease threats. In response, agricultural research is being asked to address a new and pluralist research agenda that requires both multi- and interdisciplinary responses, and the deployment of a broad assortment of new and potentially disruptive technologies, in addition to our traditional agricultural technologies.

The 'smart farming ecosystem' of the future will involve a complex range of players in the public and private sectors, requiring public sector research managers to re-evaluate their role in the national innovation system and to embrace partnering and collaboration on a global scale. To ensure continued relevance to the rapidly changing needs of society and policy makers, public research organisations will also need to strengthen procedures for involving stakeholders in programme design, priority setting and evaluating outcomes, while enhancing communication with society around the risks of new scientific applications. This in turn will require such organisations to develop a strong capacity in foresight, build core organisational competencies, and put in place new structures to facilitate greater openness to stakeholders and society.

Properly executed, new governance capacities will not only enable public research organisations to become more flexible and proactive, but also to take on a new leadership role in the development of the agriculture sector.



Gerry Boyle
Director of Teagasc

Bainistíocht straitéiseach na n-eagraíochtaí taighde

D'fhreastail breis agus 90 toscaire as 21 tír ar chomhdháil EURAGRI na bliana seo a tionóladh le déanaí in Teagasc, Baile an Áisigh, ina ndearnadh plé ar thaighde a dhéanamh in eagraíochtaí poiblí taighde agus forbartha san Eoraip, agus béim ar leith ar na dúshláin bhainistíochta straitéisí atá rompu. Mheas na toscairí na dúshláin sin sna comhthéacsanna seo a leanas: ról agus ionchais na taighde talmhaíochta atá ag athrú; bíonn ar na comhpháirtíochtaí agus geallsealbhoirí nua a sheachadadh; na struchtúir agus na huirlisí is gá chun aghaidh a thabhairt ar cheisteanna taighde nua; agus an riachtanas maidir le tuairisciú agus meastóireacht níos faireinge.

Tá dúshláin shuntasacha nua roimh thalmhaíocht sna blianta atá amach romhainn. Ní mór di níos mó bia ardchaighdeán agus sábháilte a tháirgeadh do dhaonra atá níos saibhre ná mar a bhí roimhe agus do dhaonra domhanda; agus é ag iarraidh teacht ar acmhainní nádúrtha atá ag éirí níos gainne, bithéagsúlacht agus cáilíocht an uisce a chaomhnú, éiceachórais leochaileacha a athchóiriú agus na héifeachtaí a bhaineann le hathrú aeráide a chaomhnú. Ní mór di oiriúnú do bhagairtí nua maidir le galair phlandaí agus ainmhithe.

Mar fhreagra, iarrtar ar thaighde talmhaíochta dul i ngleic le clár oibre taighde nua agus iolraíoch a éilíonn freagraí ildisciplíneacha agus idirdisciplíneacha agus an úsáid de réimse leathan teicneolaíochtaí nua agus a d'fhéadfadh a bheith suaiteach, de bheis ar ár dteicneolaíochtaí talmhaíochta traidisiúnta. Beidh réimse casta imreoirí sna hearnálacha poiblí agus príobháideacha i gceist leis an 'éiceachóras feirmeoireachta cliste' sa todhchaí, rud a éileoidh ar bhainisteoirí taighde san earnáil phoiblí a ról sa chóras náisiúnta nuálaíochta a athluacháil agus glacadh le comhpháirtíocht agus comhoibriú ar scála domhanda. D'fhothann ábharthacht leanúnach a áirithiú do riachtanais na sochaí agus an lucht déanta beartas atá ag athrú go tapa, beidh ceanglas ar eagraíochtaí taighde poiblí nósanna imeachta a neartú i ndáil le páirtithe leasmhara a bheith páirteach i ndearadh an chláir, i socrú tosaíochta agus i meastóireacht ar thorthaí, agus feabhas á chur acu ar chumarsáid leis an tsochaí maidir leis na rioscaí a bhaineann le feidhmeanna nua eolaíochta. Mar thoradh air sin, beidh ceanglas ar a leithéid d'eagraíochtaí cumas láidir i bhfadhbheathnaitheacht a fhorbairt, croí-inniúlachtaí eagraíochtúla a thógáil agus struchtúir nua a chur i bhfeidhm chun tuilleadh oscailteachta a éascú do pháirtithe leasmhara agus don tsochaí. Cuirfidh cumais nua rialachais, má chuirtear iad i bhfeidhm mar is ceart, ar chumas na n-eagraíochtaí taighde poiblí, ní hamháin a bheith níos solúbtha agus níos réamhghníomhaí, ach freisin ról ceannaireachta nua a ghlacadh i bhforbairt na hearnála talmhaíochta.

Gerry Boyle
Stiúrthóir Teagasc

Highly cited



Catherine Stanton.



Paul Allen.



Gerard Downey.

Three Teagasc researchers have featured in the 2017 World's Most Highly Cited List. Catherine Stanton is a Senior Research Officer, Teagasc (and Professor in the Department of Psychiatry and APC Microbiome Institute, UCC). Catherine's research includes nutritional aspects of dairy and functional foods, probiotic cultures, bioactive metabolite production, infant gut microbiota, and healthy proteins and fats (including conjugated linoleic acid and short chain fatty acids) that are produced by gut bacteria.

Two recently retired researchers also featured on the list. Principal Research Officer Paul Allen's research interests covered a range of cutting-edge approaches to important meat research challenges, including assurance of meat palatability, application of imaging and spectroscopic methods to prediction of meat eating quality, optimising and controlling colour in fresh meat, packaging

solutions for fresh meat, objective carcass evaluation, and innovation in healthier meat products. Gerard Downey was a Principal Research Officer and is an Adjunct Full Professor in the School of Biosystems and Food Engineering in UCD. Gerry's research field has been the application of advanced chemometrics and data analytics to vibrational spectroscopy and image analysis datasets to facilitate rapid, objective analysis of quality, authenticity and adulteration in foods and food systems.

The Highly Cited List is produced by Clarivate Analytics for the Web of Science. The list was assembled on the basis of authors' recent production of "Highly Cited Papers" – those that have enough citations to be ranked in the top 1% of peer-reviewed articles published in the same year and field. Only 14 Irish researchers feature in the 2017 World list.

Dobbin Atlantic experience

The Dobbin Atlantic Scholarship Programme aims to further academic, artistic, cultural and economic links between Atlantic Canada and Ireland. Laura Devaney, a postdoctoral research fellow in Teagasc's Department of Agrifood Business and Spatial Analysis, recently spent three weeks under the programme on a research visit to Dalhousie University, Nova Scotia, to build on her work on the Department of Agriculture, Food and the Marine (DAFM)-funded BioÉire project and the EC-funded CASA project, which examine the development and governance of the Irish and European bioeconomies.

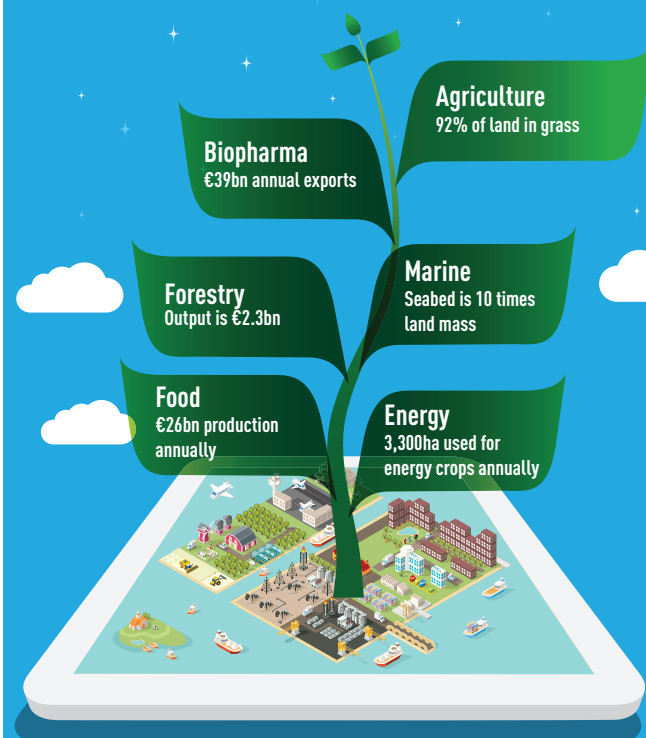
Laura explains: "I was inspired by the Programme's emphasis on the potential of shared natural resources between Ireland and Atlantic Canada across agriculture, marine and forestry economies, as well as our common technological and innovation processes, aspects that are pivotal to global bioeconomy development. With the support of Teagasc, I engaged in multiple and varied activities throughout my scholarship period, including guest lectures, researcher roundtables, panel discussions, undergraduate assemblies and Faculty Council meetings. The knowledge, networking opportunities and experience gleaned was significant, not only connecting me with researchers across the diverse Dalhousie Faculty of Agriculture, but key commodity representatives across Nova Scotia (from traditional dairy to

Christmas trees and wine!) This facilitated unparalleled insight into bioeconomy challenges and opportunities locally, and a fascinating comparison to the Irish context. I strongly urge those in a similar position to apply to the Dobbin Atlantic Programme to further their research, international networks and impact for years to come".

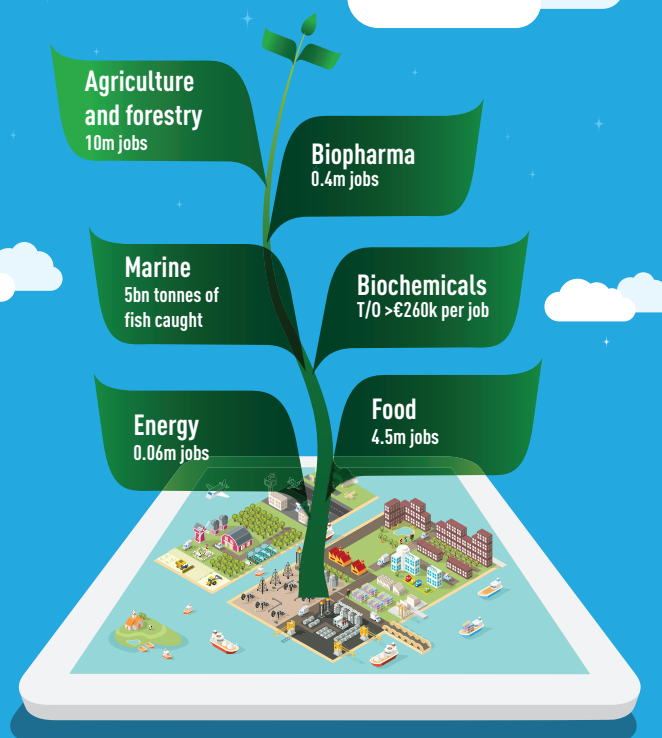


Laura Devaney, pictured with then Minister for Foreign Affairs and Trade, Charlie Flanagan, TD.

Bioeconomy 2017



Ireland



Europe

Research investment €3.7bn (BBI JU)

BIA Innovator Campus

The BIA Innovator Campus CLG, supported by Galway County Council and Teagasc, has been awarded just under €2.5m from Enterprise Ireland as part of the Regional Development Fund. It was announced by Heather Humphreys, TD, Minister for Business, Enterprise, and Innovation in December. The overall hub is expected to cost in the region of €3.9m.

Galway and the west of Ireland has been designated as a European Region of Gastronomy for 2018. Both Galway County Council and Teagasc are two of the four key partners leading this designation, working closely with Galway City Council and Galway-Mayo Institute of Technology (GMIT).

This collaboration on the development of the BIA Innovator Campus will leave a strong legacy for the region in terms of innovation facilities and champion the theme of "supporting SMEs and innovation" under the European designation.

The strength of the project was born out of the success of a strong collaboration. Galway County Council, as the local authority with enhanced responsibility for economic development, facilitated bringing together the partners at a local and national level. This was coupled with Teagasc's role as the national food and agriculture development authority. Galway and Roscommon Education and Training Board

(GRET) held a regional role, St Columba Credit Union Limited (SCCUL) played a role in terms of social enterprise, and there was input from the local community through Athenry Community Council.

The project will be rolled out over three years and is due to commence in 2018. It will create 360+ jobs in over 40 businesses across the west of Ireland, providing much needed facilities to help the food industry in the west.

Kevin Kelly, Chief Executive of Galway County Council, said the Council is: "delighted to be one of the lead partners in the BIA Innovator Campus. This is a significant step change project, which will address challenges facing the food sector through the provision of a number of supports and essential infrastructure". Gerry Boyle, Director of Teagasc, said: "Teagasc is delighted to welcome this funding for the BIA Innovator Campus proposal.

This proposal offers a unique opportunity to link with and complement the national food programmes such as FoodWorks and the Teagasc Food Gateways programme, and the Teagasc food research centres in Moorepark and Ashtown, as well as Moorepark Technology Limited. I am confident that this linkage to Teagasc will accelerate product development and ultimately increase the success of the BIA Innovator Campus".

FutureMilk

The Government has announced funding for the Science Foundation Ireland (SFI) FutureMilk Centre, bringing to 17 the total number of funded SFI research centres.

The FutureMilk Centre will be hosted by Teagasc, in partnership with the Tyndall National Institute, Ireland's national microelectronics institute, the Telecommunications Software & Systems Group (TSSG) at Waterford Institute of Technology, and the Insight Centre for Data Analytics (at UCD, NUIG and DCU). FutureMilk therefore represents a unique collaboration between agri-food and ICT research institutes, as well as leading Irish/multinational food and ICT companies.

The centre director, Donagh Berry of Teagasc, said: "The FutureMilk Centre aims to be an agent of growth for the Irish dairy industry by being a world leader in fundamental and translational research for precision pasture-based dairying. The vision of the FutureMilk Centre is to be a world leader in the agri-food technology sector through innovation and enhanced sustainability across the dairy supply chain, positively impacting the environment, animal well-being and the health of consumers.

This will be achieved by greatly improving the soil-to-gut supply chain connectivity, thereby improving resource efficiency, better meeting consumers' expectations, and improving profitability and resilience".

Sustainable dairying

The dairy unit at the Teagasc Kildalton Agricultural College, Piltown, Co. Kilkenny, is a showcase for sustainable dairying that has been set up in a joint initiative between Teagasc and Glanbia Ingredients Ireland (GII).

The farm demonstrates the best sustainable management practices that will deliver social, economic and environmental benefits on Irish dairy farms.

At Kildalton, Teagasc aims to continuously improve the sustainability of the dairy farm, seeking new opportunities to improve performance in practical and financially sound ways. The Carbon Navigator and the Nutrient Management Plan are both tools that point to how to improve performance and economic returns. Speaking at a recent open day at the farm, joint project leader Ger Shortle of Teagasc said: "Fortunately, Ireland is starting from a relatively good sustainability position; however, we need to up our game to meet the challenges created by the expected doubling of global food demand by 2050. The Kildalton Sustainable Dairy Farm Open Day aims to show farmers how to go about tackling the challenges".

He added: "The Kildalton Open Source Sustainable Demonstration Farm will play a central role in supporting the Irish dairy sector in reaching its sustainability goals, and is a valuable resource for the dairy sector".

Researcher profile

Fiona Crispie



Fiona Crispie is a technologist working on the Teagasc Next Generation Sequencing (NGS) Platform in the Food Biosciences Department, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork. Fiona graduated with a PhD in microbiology from University College Cork in 2002, and began working in Moorepark in the same year in the area of mastitis research. The project involved the

development of probiotic products for the prevention and therapy of bovine mastitis. This then led to another research position in the area of probiotic health food and functional food product development. The latter project involved using antimicrobial peptides to increase the shelf life of different food products, and also examined the gastric stability of the antimicrobials.

In 2009, Fiona was appointed to the NGS Platform in Teagasc Moorepark.

The Platform, which is partially funded through Science Foundation Ireland, is the largest such centre in Ireland and recognised both nationally and internationally as a leading

research platform. NGS has revolutionised biological research, enabling identification of all the microorganisms in a particular microbiome.

Fiona manages the NGS Platform on a day-to-day basis, advising Teagasc researchers, partner institutes and commercial customers on experimental design and the best sequencing technology to meet their needs, and supervising and training Teagasc DNA sequencing platform staff, postgraduate students and researchers in the SFI-funded Alimentary Pharmabiotic Centre on sequencing library preparation. She also acts as the Laboratory Compliance Co-Ordinator for the Food Biosciences Department.

Her research interests include: human gut microbiology – its role in metabolic and mental health and its modulation by diet and exercise; the microbiology of fermented and dairy foods; the effects of functional foods and pharmabiotic-producing probiotics on the human gut microbiome; and, the role of the rumen microbiome in modulating milk production and methane emissions.

Originally from Kerry, Fiona enjoys hiking, swimming and running, and completed her first half marathon in 2014. She lives with her husband, who is a part-time farmer, and her two small boys, and breeds pedigree cattle, which the whole family enjoys showing at summer sales.

Food innovation hub

Teagasc will receive €8.8m of funding from the exchequer for a new food innovation hub based at Teagasc Moorepark. Speaking at the launch, An Taoiseach Leo Varadkar, TD, said: "Small and medium sized agri-food businesses are already preparing for Brexit by taking an innovative approach and opening up new European and international markets outside of the UK. This new National Food Innovation Hub will help Irish businesses to innovate and expand, keeping our agri-food sector competitive and attracting investment in a post-Brexit world".

Speaking at the announcement, Minister for Agriculture, Food and the Marine Michael Creed, TD, said: "Food Wise 2025 identified research, development and innovation as key drivers of competitiveness in the agri-food sector. In this context, it recommended collaboration between industry and the research community to advance research and new product innovation". The primary objective of the National Food Innovation Hub is to create a business innovation network involving dairy companies, Moorepark Technology Ltd (MTL), incubator companies and public-private partnership-based R&D programmes with a research focus on food processing, quality and nutrition. It involves constructing up to 12 customer application suites containing office and laboratory space, so that each company can have an on-campus presence to conduct new product development, etc.



Mark Fenelon, Head of the Teagasc Food Research Programme (left), and Frank O'Mara, Director of Research in Teagasc, meeting the Taoiseach, Leo Varadkar, TD, and the Minister for Agriculture, Food and the Marine, Michael Creed, TD, to discuss the new National Food Innovation Hub planned for Teagasc Moorepark.

The National Food Innovation Hub will be directly linked to both the Teagasc Food Research Centre and MTL to engender close collaboration between the research centres and the companies located on the Moorepark campus. It is envisaged that this unique food cluster will stimulate intensive collaboration between companies and Teagasc researchers to create a platform for innovation, economic growth and job creation.

Welcoming new Walsh Fellows

Making the move from undergraduate to postgraduate study is a giant leap in any young researcher's career. "Typically students go from a class of hundreds to a class of one, with a unique exam, and the starting point is an unanswered question. Add in possible changes in location, culture and study methods, and it's no wonder that the transition to PhD researcher is one of the most stressful times of a student's life," says Joanne Fearon, Programme Manager of the Agri-Food Development Programme, who facilitated a recent induction day for new Teagasc Walsh Fellows. Director of Research, Frank O'Mara, welcomed the students to the organisation and gave them a brief rundown of what Teagasc does on local, national and international stages. Lance O'Brien, Walsh Fellowships Programme Director, talked to the students about what it means to be a Walsh



Students recently attended the Walsh Fellowships induction day.

Fellow, and Sarah O'Brien from VHI walked them through the student assistance programme.

The event was organised by Hilary King, Walsh Fellowships Scheme Administrator.

End of project reports on T-Stór

From 1998 to 2008, Teagasc researchers published End-of-Project Reports for all completed research projects.

These were brief reports designed to communicate our research results to a wide audience and as such are an important record of Teagasc research. The reports have now been added to T-Stór, Teagasc's open-access repository. "This is a significant addition to T-Stór and makes a lot of older Teagasc research available to the

world," says Máire Caffrey, Teagasc's Head Librarian. All the documents in this unique and valuable collection are free to download and can be browsed at: <http://t-stor.teagasc.ie/handle/11019/963>. From 2008 onwards, the End-of-Project report system was replaced by Technology Updates. These can be accessed on the Teagasc Publications website – www.teagasc.ie/publications/.

Festival of Farming and Food

Visitors to 'A Taste of Food Science & More', an open evening for the general public at Teagasc Ashtown Research Centre, Dublin.

During Science Week, TEAGASC hosted a series of events around the country as part of the Festival of Farming and Food – SFI Science Week at Teagasc.

Teagasc hosted a series of exciting events for Science Week, which took place during November 12-19. Teagasc's research centres around the country opened their doors for school and college visits, where students got to perform hands-on experiments and find out about careers in science, technology, engineering and maths (STEM).

Teagasc also hosted two events for the general public. A Taste of Food Science & More was an open evening held at Teagasc Food Research Centre, Ashtown, in Dublin. An evening of science talks – '60 Minute Science' – was held at Visual Carlow and hosted by RTÉ's Jonathan McCrea.

Catriona Boyle, Teagasc Senior Research Officer – Science Communications and Outreach, said: "The theme of this year's event is 'Believe in Science'. Attendees learnt about a wide variety of topics and how they apply to their everyday lives, including: food for health; food product development and improvement; food safety; sustainability of animal and plant production; healthy soils and biodiversity; and, the development of rural areas".

Teagasc Women in STEM

Teagasc also launched a new publication, 'Teagasc Women in STEM', this Science Week. According to Jane Kavanagh, Head of Research Operations: "Teagasc is committed to promoting careers in STEM and is actively engaged in many science outreach events, such as Science Week. The purpose of this publication is to highlight women who are working in STEM, to show the diverse range of careers available in agri-food research arising from

studying science-related courses at second and third level, and to hopefully provide female students with potential role models that they can relate to".

Acknowledgements

The Teagasc Science Week committee is made up of Máire Caffrey and Bridin McIntyre (Ashtown), Norina Coppinger (Athenry), Orla Keane and Kieran Meade (Grange), Alison Maloney, Catriona Boyle and Hilary King (Head Office), Karen Daly (Johnstown Castle), Emer Kennedy and Niamh O'Brien (Moorepark), and Gerard Hehir (Oak Park), and is project managed by Catriona Boyle. As well as the committee, many staff and student volunteers contribute to Science Week's success. The Festival of Farming and Food was supported by Science Foundation Ireland and Teagasc core funding.

Author

Catriona Boyle

Senior Research Officer – Science Communications and Outreach, Teagasc Head Office, Oak Park, Carlow
Correspondence: catriona.boyle@teagasc.ie

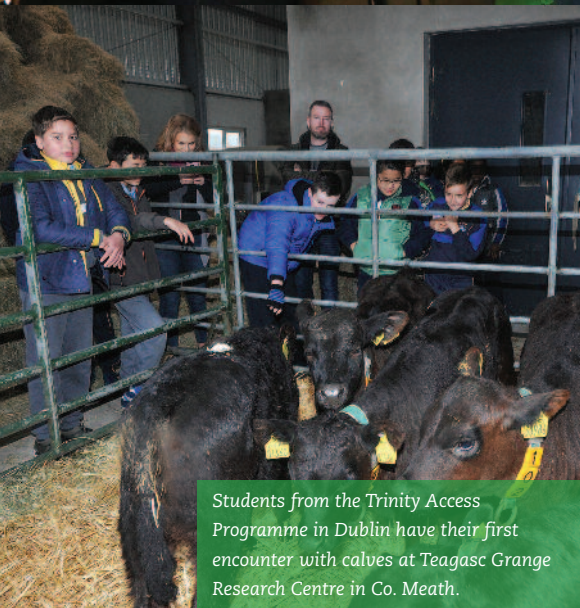


“Teagasc is committed to promoting careers in STEM and is actively engaged in many science outreach events, such as Science Week.”

FEATURE



Visitors at the '60 Minute Science' open evening for the public at Carlow Visual.



Students from the Trinity Access Programme in Dublin have their first encounter with calves at Teagasc Grange Research Centre in Co. Meath.



Emer Kennedy addresses students from Loreto Secondary School, Fermoy, at Teagasc Moorepark Research Centre, Fermoy, Co. Cork.



Fergus Meade, a postdoctoral researcher at Teagasc Crops, Environment and Land Use Research Centre, Oak Park, Carlow, talks about breeding potatoes for perfect fry colour.



Students Zoe Lyons and Emily Carr from Claregalway College, Co. Galway, at the Teagasc Athenry Science Week open day.

Stepping on the gas

Ten new transnational research projects on monitoring and mitigation of greenhouse gases from agriculture and forestry were launched recently as part of the **TEAGASC**-led FACCE ERA-GAS ERA-NET Cofund.



The agricultural sector in Europe faces significant challenges in curbing greenhouse gas (GHG) emissions while maintaining food security and sustainability in a changing climate. Projected increases in the world's population and a shift in emerging countries towards higher consumption of resource-intensive food items will put unprecedented pressure on global agriculture. To meet this demand, agriculture will have to produce almost 50% more food, feed and biofuel in 2050 than it did in 2012, according to the Food and Agriculture Organisation (FAO) of the United Nations. This will require the development of innovative farming and forestry systems that ensure sustainability while increasing productivity.

Our aim is to strengthen the transnational co-ordination of research programmes in Europe and provide added value to research and innovation on GHG monitoring and mitigation.

A transnational approach for a global problem

Developing the knowledge and technologies to tackle these global societal challenges will require a co-ordinated international approach. In particular, innovative GHG mitigation and monitoring solutions that extend beyond the local context are needed. While the EU Framework

Programme for Research and Innovation, Horizon 2020, is an important source of research funding in the EU, most funding is still controlled nationally. An ERA-NET Cofund is a funding mechanism whereby *national* money is pooled to fund *transnational* projects. Cofunding is also provided by the European Commission through Horizon 2020. FACCE ERA-GAS is the ERA-NET Cofund for Monitoring and Mitigation of Greenhouse Gases from Agri- and Silvi-culture. The FACCE ERA-GAS consortium comprises funding agencies and project partners from 19 organisations across 13 European countries. Teagasc is the overall co-ordinator of the ERA-NET, which is only the second time that an Irish organisation has led this type of project.

Our aim is to strengthen the transnational co-ordination of research programmes in Europe and provide added value to research and innovation on GHG monitoring and mitigation. Through this enhanced co-operation and better alignment of national research priorities, FACCE ERA-GAS activities will have the scale and scope necessary to maximise the impact of GHG research activities in Europe (**Figure 1**).

2016 joint call for proposals

In March 2016, the FACCE ERA-GAS consortium pooled resources to launch the 2016 call for transnational research projects, co-funded by the European Commission. New Zealand, represented by its Ministry for Primary Industries, also contributed to the call. The total call budget was €14.1m. Each project consortium had to include partners from at least three different European countries participating in the call. Proposals were subjected to a two-stage evaluation process by an international evaluation committee, which was managed by the Research and Codex Division of the Irish Department of Agriculture, Food and the Marine (DAFM). Ten projects were finally selected for funding, involving 71 project partners from 39 different research institutions and companies



Project round tables during the first FACCE ERA-GAS Research Programme Meeting allowed for networking and showcasing of the new projects.

across 13 European countries, New Zealand and the US. Over the next three years, these projects will conduct collaborative research to develop improved GHG mitigation solutions, reporting mechanisms and policy instruments for the agriculture and forestry sectors.

Official launch

On October 10, 2017, the 10 new projects were officially launched as part of the first FACCE ERA-GAS Research Programme Meeting in Wageningen University & Research, the Netherlands. The two-day event showcased the new projects and provided opportunities for networking between scientists, research funders and stakeholders. Speaking at the meeting, Dr Frank O'Mara, Teagasc Director of Research, highlighted the urgent need for international co-operation to tackle the global challenge posed by climate change and food security: "Efforts are required to increase the GHG efficiency of food, feed and fuel, enhance carbon sinks and refine national inventories. By conducting research in integrated,

transnational partnerships, FACCE ERA-GAS projects will be able to develop and implement joint solutions that achieve these objectives". Future events and activities are planned over the lifetime of FACCE ERA-GAS to showcase project results, engage with stakeholders and policymakers, and co-ordinate efforts with global GHG networks. This will ensure that the new knowledge generated is shared and implemented for wider societal benefit.

Acknowledgements

The FACCE ERA-GAS project receives funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 696356. We thank the team at Wageningen University & Research for all their help in organising and hosting the meeting, especially Christine Bunthof (Senior Advisor and Account Manager Joint Programming) and Herman van Keulen (Communications Project Manager). For more information on FACCE ERA-GAS and the new funded projects, visit www.eragas.eu or follow @FACCE_ERAGAS on Twitter. FACCE ERA-GAS was initiated by the EU Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI).

For more information on FACCE-JPI: <https://www.faccejpi.com/>.

Authors

Órlaith Ní Choncubhair

Research Officer, Research Support Office, Teagasc Head Office, Oak Park, Carlow

Correspondence: orlaith.nichoncubhair@teagasc.ie

Frank O'Mara

Director of Research, Teagasc Head Office, Oak Park, Carlow

Raymond Kelly

Head of Research Support, Teagasc Head Office, Oak Park, Carlow



FIGURE 1: Through enhanced co-operation and better alignment of research efforts, FACCE ERA-GAS aims to address the issue of climate change more effectively.

Vision of Research and Innovation competition 2017

*Monitoring of Grass Changes using Drone Imagery
by Juliette Maire.*

The second Teagasc Vision of Research and Innovation image competition launched in May 2017. The competition closed on October 2 and the judging panel comprised Mark Moore (Teagasc, editor of *Today's Farm*), Jack Caffrey (Pimlico Project, *Irish Farmers Journal*), and John Beeching (University of Bath, UK).

The competition invited all Teagasc staff and students to submit digital images created in the course of their work, with the aim to find the most innovative and compelling images showing the range of research and innovation activities taking place across Teagasc. Selected images will be used to promote Teagasc research and are featured in a 2018 calendar.

The winning images were: 'Love Touch' by Oceane Schmitt; 'Our (Shared) Ocean Wealth' by Laura Devaney; 'Future Homes for Bacteria' by Conor Feehily; 'Inside a Flower of Wheat' by Dheeraj Rathore; 'Collaboration, Technology and Tradition' by Colum Kennedy; 'Sheep Doing What Sheep Do Best' by Stephen Bleakley; 'Where is all the Sitka gone?' by Susan Foreman; 'Grazing at Dawn' by Ben Lahart; 'Best of the Best' by Stephen Byrne; and, 'Box Cam' and 'Rust in Peace', both by Brian McGuinness.

The overall winner was Juliette Maire's image 'Monitoring of Grass Changes using Drone Imagery'. Juliette's photo shows drone imaging captured during her PhD Walsh Fellowship: "Scaling reactive nitrogen mitigation in grasslands systems".

Frank O'Mara, Teagasc Director of Research, congratulated all of the entrants for the extremely high standard of images submitted and, in particular, thanked the judges for their careful deliberation in selecting the winning images. Speaking of the winning image judge Mark Moore said: "Juliette's image is striking due to its representation of an everyday scene from an unexpected viewpoint. Aside from the aesthetic appeal

of the image, the scientific concepts behind her PhD work on greenhouse gas emissions are apparent from this unexpected perspective".

The next Vision of Research and Innovation image competition launches in May 2018.

"Juliette's image is striking due to its representation of an everyday scene from an unexpected perspective."

Authors

Kim Reilly

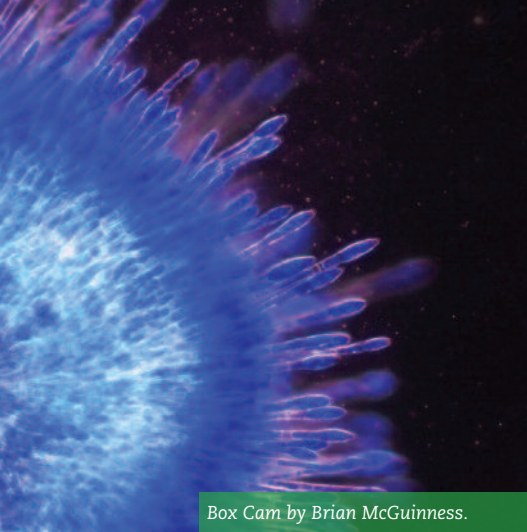
Research Officer, Research Support Office, Teagasc Food Research Centre, Ashtown, Dublin 15

Correspondence: kim.reilly@teagasc.ie

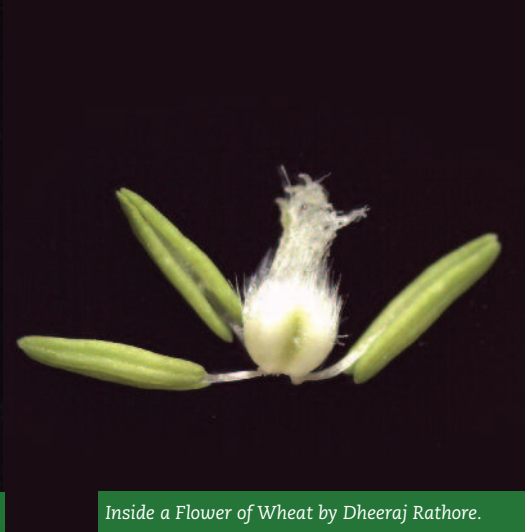
Raymond Kelly

Head of Research Support, Teagasc Head Office, Oak Park, Carlow





Box Cam by Brian McGuinness.



Inside a Flower of Wheat by Dheeraj Rathore.



Rust in Peace by Brian McGuinness.



Where is all the Sitka gone? by Susan Foreman.



Sheep Doing What Sheep Do Best by Stephen Bleakley.



Our (Shared) Ocean Wealth by Laura Devaney.



Love Touch by Oceane Schmitt.



Grazing at Dawn by Ben Lahart.



Future Homes for Bacteria by Conor Feehily.



Best of the Best by Stephen Byrne.



Collaboration, Technology and Tradition by Colum Kennedy.



Rising stars

TEAGASC is involved in the FOODstars project, which is strengthening research potential in the Western Balkans.

FOODstars is a Horizon 2020-funded project aimed at strengthening the research capacity of the Institute of Food Technology (FINS) of the University of Novi Sad, Serbia, in close collaboration with two leading international research institutions: Teagasc and the University of Bologna, Italy. In progress since early 2016, FOODstars covers themes such as raw materials and food ingredients for novel food solutions, innovative food product development, and characterisation of food products, as well as intellectual property rights, knowledge dissemination and scientific networking. Knowledge transfer has been achieved through training courses, schools, themed workshops, study visits, joint publications, and various outreach activities, helping FINS to carry out efficient and high-quality research that will be transferred to industry.

Background

FOODstars was conceived in 2015 as a response to the need identified by the scientists working at FINS to strengthen their research potential and innovation capacity. As FINS is already recognised as one of the leading institutes of food technology in the Western Balkans region, the gain of additional applied knowledge and the enhancement of international co-operation with high-quality EU research organisations promoted by FOODstars is leading to direct responses in terms of economic and social development. An especially important outcome of the project is the creation of career development opportunities, encouraging young researchers to develop their science career in Serbia and thus reducing the ever-growing 'brain drain'.

Outcomes

Within the three-year programme, 12 one-month training courses for 31 researchers from FINS, four two-week schools involving nine researchers, and two study visits for four researchers are planned. Some of the past activities include:

- a two-day workshop on 'New value from food processing waste streams and by-products' (FINS, March 2016) organised by Teagasc researchers;
- two one-month training courses in 'Innovative technologies for advanced food processing' (Teagasc Ashtown, April and August 2016);
- a one-week school on 'Methods of optimisation for advanced food processing' organised by Teagasc Ashtown's researchers (FINS, May 2016);
- two one-month training courses on 'Novel methods of isolation and determination of plant bioactives' (University of Bologna, June 2016 and February 2017);
- a 30-day training course in 'Antimicrobial activity of natural molecules and functionalised polymers' (University of Bologna, September 2016);
- a one-month training course in 'Consumer testing methods' (Teagasc Ashtown, September 2016);
- a three-day workshop on 'Recent developments in microencapsulation of food ingredients' presented by researchers from Teagasc Ashtown (FINS, October 2016);
- a two-day workshop on the 'Protective/preventive role of bioactive food components in human health' organised by researchers from the University of Bologna (FINS, December 2016);
- two one-month training courses in 'Encapsulation of food ingredients' (Teagasc Ashtown, February and August 2017);
- a three-day workshop on 'Green extraction techniques in food science' offered by scientists from the University of Leiden, The Netherlands (FINS, March 2017);
- a two-day workshop entitled 'Creation of a successful business plan' (FINS, May 2017); and,
- a two-week school on 'Food authenticity and detecting and quantifying food adulteration' (Teagasc Ashtown, UCD and DIT, October 2017).



FOODstars involved a number of training and education opportunities in FINS, Teagasc, and the University of Bologna, Italy.

Positive response to FOODstars from FINS researchers

"The 'Green extraction techniques in food science' workshop held last March at FINS was particularly interesting because it included two practical sessions by Dr Erica G. Wilson from Leiden University in The Netherlands.

The first session concerned the preparation of natural deep eutectic solvents (NADES). The participants were separated into several groups, and each group was asked to prepare a specific NADES. The second session was about the quantification of rutin, quercetin and quercitrin in different NADES extracts using HPLC-DAD," said Miona Belović, Research Associate at FINS.

"Another interesting event was the participation of FOODstars in the International Festival of Science and Education held on May 13-14, 2017, in the Central Campus of the University of Novi Sad. FOODstars organised a survey as part of the workshop 'Food without mistakes', prepared by FINS.

Children were asked to write down answers to the questions 'What would you want to eat in the future?' and 'Your dream meal!', and their name and age. Each hour, the most imaginative answer was chosen and the winner received a prize – a balloon, puzzle or candy bar." Dubravka Škrobot, Research Associate at FINS, says FINS researchers are very proud of FOODstars, as they have been given the opportunity to work with experts and learn about new food technologies that can be transferred into Serbian industry: "I participated in two one-month courses at Teagasc, one in Ashtown and the other in Moorepark. I am very satisfied with the knowledge gained in the 'Consumer testing methods' training organised by Dr Maeve Hinchion, during which I could share my knowledge and experiences with colleagues working in the field of sensory analysis. FOODstars also enabled me to meet a lot of young researchers, to learn about the Irish customs and people, and to enjoy Ireland's beautiful nature".

An especially important outcome of the project is the creation of career development opportunities, encouraging young researchers to develop their science career in Serbia and thus reducing the ever-growing 'brain drain'.

Based on the outcomes from the first half of the project, the FOODstars leaders Milica Pojić and Aleksandra Mišan – Research Associates from FINS – believe the project will increase the participation of Serbia and countries from the Western Balkans in international research.

Acknowledgements

FOODstars receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 692276. The FOODstars team acknowledges the work of the many FINS, UNIBO and Teagasc staff who have been contributing to its success. Further information is available at <http://FOODstars.uns.ac.rs/>.

Authors

Camila Perussello

Research Officer, Department of Food Chemistry and Technology, Teagasc Food Research Centre, Ashtown, Dublin 15
Correspondence: camila.perussello@teagasc.ie

Brijesh Tiwari

Principal Researcher Officer, Department of Food Chemistry and Technology, Teagasc Food Research Centre, Ashtown, Dublin 15





Energy debate heats up

Improving the level of efficiency on Irish farms is a key component to ensuring their resilience as they face demanding economic and environmental challenges. **TEAGASC'S** Barry Gaslin outlines the main topics covered at the recent 'Energy in Agriculture' event.

Despite recent reductions in energy prices there is still great scope on many farms to reduce energy usage and there are opportunities for farmers to invest in renewable energy technologies, which will lower the required use of fossil fuels in Ireland. The primary objective is to improve the efficiency of systems by insulating, and by using better lighting systems and more energy-efficient technologies. This cuts the kilowatt hours (kWh) or units of energy needed. It's only then that you decide on what renewable technologies can be deployed to take the place of the fossil fuel energy-producing systems.

There has been an increasing scrutiny of greenhouse gas (GHG) emissions in recent years. Ireland has a very high dependence on the agricultural sector, with gross agricultural output (GAO) valued at €6.92 billion in 2016. The beef and dairy sectors account for 38.8% and 29.5% of this, respectively. As a consequence of this our agricultural percentage of our overall GHG emissions is relatively high compared to most other European countries. Agriculture in Ireland contributes about 33% of our national GHG emissions due to the fact that we have a high bovine component in our national output from agriculture. By improving our energy efficiency, and also investing in renewable technologies, we can reduce GHG emissions coming from the agricultural sector per unit of output. This will also enhance the green credentials of the agricultural sector and improve the marketability of Irish produce.

Energy efficiency measures

There are a number of areas where farms can undertake measures to improve their energy efficiency:

- choosing an energy supplier with the most competitive tariffs;
- energy-efficient lighting;
- insulating buildings and pipework;
- installing control systems in more intensive energy systems;
- basic maintenance, such as removing dust from the fins of chill units or from radiators; and,
- replacing old inefficient equipment such as motors or pumps, e.g., variable speed drives, etc.

There are so many agencies with which renewable project developers must work to get projects off the ground that it effectively kills off most projects.

Supports for renewable technologies

The uptake of renewable energy sources requires support schemes to encourage their deployment. As technology costs decrease, so too will the level of supports available. We need a clear matching of technology costs to the supports that will be put in place. The long-awaited Renewable Heat Incentive (RHI) will bring advancements in renewable heat deployment and we are currently awaiting a consultation on the Renewable Electricity Support Scheme. These supports will radically change our approach towards energy use and technology adoption over the coming years.

Barriers to renewables

The procedures for approvals are quite long in Ireland and this adds to the cost of developing renewable projects, especially for renewable electricity. Planning and approval, together with grid connection, are notable costly delays. There are so many agencies with which renewable project developers must work to get projects off the ground that it effectively kills off most projects.

Benefits of renewables

Denmark sees renewables as a launch pad for exports. Renewable energy is an integral part of German industrial policy. This is a strategy to keep their industry competitive. Spain launched into the renewable space because it wanted to be a global player in renewable energy. The question for Ireland is: will we be dragged kicking and screaming into the renewable space, or will Ireland be centre stage and grasp this opportunity? It will cost money to achieve our national renewable targets and to encourage the deployment of renewables. We have to look at this as an opportunity and at what renewables can do for the economy as a whole.

Heating the farm with solar

Solar hot water systems would mainly be used in the high-energy agricultural sectors. A typical dairy cow would use approximately 350kWh of electricity per year, of which around 40% (140kWh) is used for heating water. The combination of both direct and diffuse sunlight that can be trapped for use is between 1,000 and 1,100kWh per square metre each year. Solar heat is a technology supported by an RHI in Britain. If such measures are included in the planned RHI scheme here, it will be attractive to dairy farmers.

Solar photovoltaic

There has been a recent frenzy about ground-mounted solar photovoltaic (PV) in farming circles over the past 18 months. This is mainly due to the anticipated supports for renewable electricity to meet our renewable targets. Solar PV can also be roof mounted and is a well-proven technology. The cost of PV has reduced by 60% over the past seven years. In order to increase the level of renewable energy production from PV, Irish farmers will require some level of support. This could be through a feed-in tariff (FIT) or contracts for different types of electricity auction support. Each kW of installed PV will give about 800kWh of electricity output.

A typical 12kW PV panel array would cost about €12,000 or €1,000 per kW. If you offset your current electrical requirement of €0.15c/kWh, which equals to about €120 per kW or €1,440 for a 12kW panel, the payback will take over eight years. While tax deductions are available, a payback in excess of eight years is not attractive and this will require some level of support to attract investment.

It will cost money to achieve our national renewable targets and to encourage the deployment of renewables. We have to look at this as an opportunity and at what renewables can do for the economy as a whole.

Carbon footprints

Each kWh of electricity generated from a conventional power station using either coal, oil or gas emits, on average, 0.47kg of carbon dioxide to the atmosphere. A typical 12kW PV system will generate about 9,600kWh of electricity per annum, which saves about 4.5 tonnes of emissions to the atmosphere.

Conclusion

The agricultural sector is currently faced with two defining global challenges: the need to produce more food in a sustainable way to provide for an increasing global population; and, the essential need to avoid global warming approaching dangerous levels. Local agriculture can play a major role in meeting these dual challenges. This will require good government leadership. We need buy-in from the ground up into this energy transition. We have to look at the opportunities and benefits that will emerge from facilitating this, and not just focus on the costs.

Author

Barry Caslin

Specialist – Energy and Rural Development, Teagasc, Longford
Correspondence: barry.caslin@teagasc.ie



Purple patch

TEAGASC research has contributed to recommendations on iodine supplementation in the Irish dairy industry.

Grass grown in Ireland is generally deficient in iodine, but excessive supplementation with iodine results in excessive iodine concentrations in milk. A recent industry-wide initiative to reassess the iodine nutrition of lactating dairy cows is having a beneficial effect on milk iodine concentrations.

Iodine

Iodine is an essential trace element for both humans and animals. The only known roles of iodine are related to its incorporation into the thyroid hormones, thyroxine (T4) and triiodothyronine (T3). These hormones control oxidation rate and protein synthesis in all cells, and hence regulate the rate of energy metabolism in the body. Approximately 80-90% of dietary iodine is absorbed, and most of the iodine not taken up by the thyroid gland is ultimately excreted in urine and milk.

Deficiency symptoms

Clinical iodine deficiency results in goitre (enlargement of the thyroid gland), which is easily recognised and is specific for iodine deficiency.

The first indicator of iodine deficiency in a herd is goitre in newborn calves. Iodine deficiency may also result in hairless, weak or dead calves, reduced reproductive performance marked by irregular oestrous cycles, poor conception rates, abortions and retained placenta.

Toxicity symptoms

The upper limit for iodine tolerance in cattle is 50mg/kg DMI. Exposure to excess iodine results in hypothyroidism, because of response inhibition of triiodothyronine synthesis. Nasal discharge, conjunctivitis, coughing, hair loss and dermatitis have been observed following excessive iodine consumption for prolonged periods (years).

Recommendations for iodine intake

International dairy cattle mineral nutrition reference literature indicates that the dietary iodine requirements for lactating dairy cattle are similar in both confinement (USA, UK) and pasture-

based systems (New Zealand; **Table 1**). Rogers and Gately (1998) recommended that dairy cows (dry or lactating) are supplemented with 12-60mg/cow per day, with 12mg meeting the requirements of most animals where supplementation is needed, and that any increase in supplement above 12mg is only required in animals diagnosed with severe deficiency.

Iodine in the diet of Irish dairy cows

Iodine intake in grazed grass and in the total diet was assessed in a Teagasc survey of seasonal variation in mineral nutrition on 44 dairy farms conducted during the 2013 grazing season across the main dairy regions of Ireland (**Figure 1**). On average, a pasture-only diet would have provided 0.25mg iodine per kg DM (range: 0.04-0.98mg).

Based on the National Research Council guideline of 0.5mg/kg DM, a pasture-only diet would have provided 50% (range: 8-190%) of the lactating cow iodine requirements. Of the grass samples analysed, 87% contained less than 0.5mg iodine per kg DM. Hence, supplemental iodine is necessary for the majority of pasture-based cows in Ireland.

While grass was iodine deficient in the 2013 survey, the total diet supply of iodine was generally excessive. When concentrate supplements were fed (especially during March and May), iodine was generally over-supplied in the total diet, with average estimated intakes exceeding 400% of requirements.

Implications of excess iodine on milk iodine concentrations

Iodine toxicity is especially important for newborn infants, who are more sensitive to it because of an immature thyroid gland. Infant milk formula (IMF) is a key market for the growing Irish dairy industry, but milk produced when cows are fed surplus iodine in supplemental concentrate is generally unsuitable for inclusion in IMF.

Iodine concentrations in raw milk (bulk tank) should be maintained between 20 and 150µg/kg. This ensures that cows are maintained in adequate iodine status, and that the milk produced is safe for a diverse product portfolio.

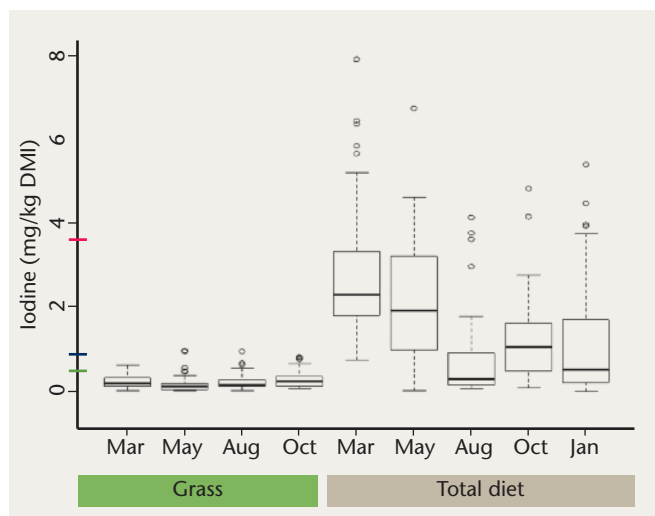


FIGURE 1: Grass iodine content and total iodine intake (mg/kg DM) at five time points in March, May, August and October 2013, and January 2014 (total only). The National Research Council (2001) recommendation is 0.5mg iodine/kg DM for lactating cows (indicated by the green bar on the y-axis). The current Irish recommended lower (12mg/day) and upper (60mg/day) iodine supplementation rates equate to 0.9mg/kg DMI and 3.63mg/kg DMI (blue and red bar on the y-axis, respectively).

Reassessment of Irish recommendations

Until spring 2017, the animal compound feed industry in Ireland had adopted using 60mg iodine per day as the 'normal' supplementation rate rather than 12mg iodine per day as originally recommended. In January 2017, all manufacturers of compound feed in Ireland were requested to revert to the recommended rate of 12mg/d. In Moorepark research herds, supplemental iodine intake and milk iodine concentrations measured in September 2017 are illustrated in **Figure 2**. Herd 1 and Herd 2 were receiving close to the target iodine supplementation rate (dashed red line), but Herd 3 was receiving surplus supplemental iodine. Consequently, the bulk tank milk for Herd 1 and Herd 2 was well below the upper limit for milk iodine concentration (dashed blue line), but Herd 3 was exceeding the upper limit. The results clearly indicate that it is feasible to maintain milk iodine concentration at between 20 and 150µg/kg by providing approximately 12mg iodine per day. Initial feedback from processors in 2017 indicates that the iodine specifications for the IMF market have been easier to achieve than in previous years, reflecting the prompt changes to the iodine inclusion rate implemented by the majority of feed manufacturers in line with Teagasc guidelines. Co-operation from dairy farmers, the feed industry, dairy nutritionists and veterinarians is required to continue using the recommended 12mg per day of iodine, facilitating profitable and sustainable growth of the Irish dairy industry.

Acknowledgments

We gratefully acknowledge the farmers that participated in the 2013 mineral survey. The research was supported by Teagasc core funding and the Dairy Levy Trust.

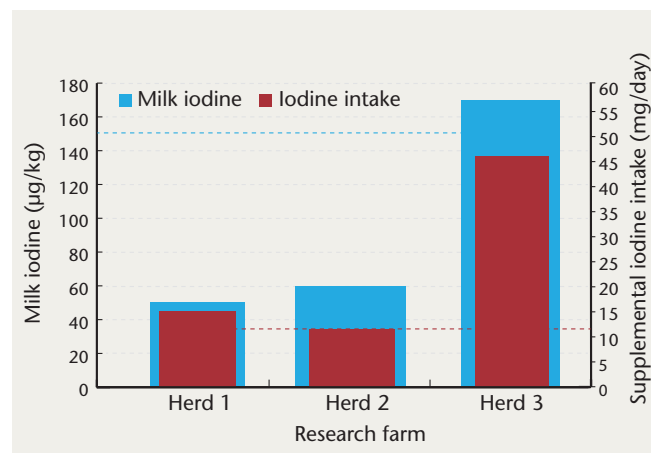


FIGURE 2: Supplemental iodine intake and bulk tank milk iodine concentrations in three research herds during September 2017.

Table 1: Summary of the recommended iodine requirements in lactating cows in different countries.

Country	Iodine requirement (mg/kg DMI)
USA, ¹ UK	0.5
Germany ²	0.5
New Zealand ³	0.5
Ireland ⁴	0.9 to 3.6

References

1. National Research Council. (2001). *Nutrient Requirements of Dairy Cattle* (7th revised ed.). Used as reference value in both the USA and UK.
2. German Society of Nutrition Physiology. (2006). *Empfehlungen zur Energie und Nährstoffversorgung von Schweinen*. Nr. 10, DLG-Verlag, Frankfurt.
3. Grace, N., Knowles, S. and Sykes, A. (2009). 'Managing Mineral Deficiencies in Grazing Livestock.' Occasional Publication No. 15, New Zealand Society of Animal Production.
4. Rogers, P.A.M. and Gately, T.F. (1998). 'Control of mineral imbalances in cattle and sheep: a reference manual for advisers and vets.' Published by Teagasc, Dublin.

Authors

Stephen Butler

Principal Research Officer, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork
Correspondence: stephen.butler@teagasc.ie

Francis Curran

Teagasc Walsh Fellow, Moorepark, Fermoy, Co. Cork.

David Gleeson

Experimental Officer, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork



Dried, sealed, delivered



With more scrutiny than ever on the use of antimicrobials, especially in animals, **TEAGASC** researchers looked at methods to reduce their use and maintain low levels of mastitis in dairy herds.

Mastitis is a costly disease that impacts on animal welfare, milk quality and farm profit. Not alone is mastitis associated with reduced milk yield, but additional costs related to diagnostic and treatment expenses and extra labour inputs also accrue. In addition to reducing farm income, mastitis can also negatively impact on the image of the dairy sector, due to animal welfare and milk quality issues. Furthermore, there are public health concerns due to the increased risk of residues through 'improper' use of antimicrobials. Mastitis is a disease that can threaten udder health in both heifers and adult cows. Herds are considered to have problems with heifer mastitis if >15% of the heifers have intra-mammary infections around the time of calving. Owners of such herds should instigate investigations and implement heifer mastitis prevention and control measures. As heifer mastitis is a multifactorial disease, a multifaceted approach to prevention and control is required. Commonly recommended interventions include housing heifers in a clean environment, minimising stress and optimising general farm udder health to minimise infection pressure from older cows to younger heifers. While some studies have investigated the use of pre-partum antibiotic treatment in heifers, this is not considered prudent use of antimicrobials.

Another area of concern regarding antimicrobial use is blanket dry cow therapy (BDCT). BDCT involves the administration of long-acting antimicrobials into all quarters of all cows at drying off. Due to the success of mastitis control programmes involving BDCT, regular milking machine maintenance and improved udder hygiene, many animals are now uninfected at drying off. As a result of these favourable trends, and the growing fears over antimicrobial resistance, it has been suggested that BDCT is no longer required. As the majority of antimicrobials used in dairy cattle are administered via the intra-mammary route, trials have been conducted at Teagasc Moorepark to examine the potential for reduced use of antimicrobials and also non antimicrobial-based mastitis control programmes.

Selective dry cow therapy

Unlike BDCT, where all cows receive antibiotics, selective dry cow therapy (SDCT) involves targeted use of antibiotic treatment only in those cows that have an intra-mammary infection at drying off. In quarters uninfected at drying off, teat seal (TS) is administered instead, which can prevent new infections during the dry period. The seal forms a physical barrier in the teat canal, preventing the entry of bacteria capable of causing mastitis.

In herds with somatic cell counts (SCC) of <200,000 cells/ml, <2% clinical case rate in the last three months, and where individual cow milk recording data is available, SDCT may be worth considering. When administering TS, strict hygiene is essential (**Figure 1**). Our aim was to investigate SDCT and the administration of TS to heifers in an Irish setting.

SDCT study

The experiment was run in the Clonakilty research herd across 2015 and 2016, and was repeated in the Clonakilty, Moorepark and Curtins research farm herds in 2017 (the study is currently ongoing). At drying off, cows were deemed eligible for inclusion if their SCC had not exceeded 200,000 cells/ml and they had not presented with a clinical case of mastitis throughout the previous lactation. In total, 364 cow lactations were recruited to the study across the three years. Eligible cows were randomly assigned to treatment 1 (TS only; n=184) or treatment 2 (TS plus antibiotic (cefalonium); n=180). To determine SCC and bacteria present, quarter sampling was conducted at drying off (pre treatment) and at three time points post calving: (1) immediately post calving; (2) two weeks post calving; and, (3) mid lactation. Weekly post-calving milk recording data provided additional SCC measurements.

Results

Initial results indicate that the SCC of TS-only cows was statistically greater than those cows that received both antibiotic and TS

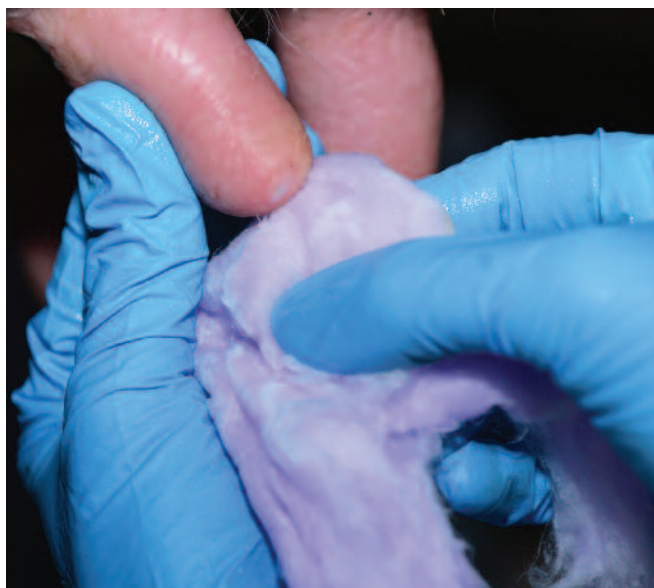


FIGURE 1: Strict hygiene is essential when infusing teat seal.

(unadjusted SCC 70,374 vs 46,673: first 120 days in lactation). The proportion of cows in each treatment group that had an SCC recording of >200,000 cells/ml during the first 120 days post calving is illustrated in **Figure 2**. The majority of cows in both treatments (>80%) maintained an SCC of <200,000 cells/ml, but cows administered TS only were 2.9 times more likely to have an SCC reading >200,000 cells/ml within the first 120 days of lactation. Initial results indicate that a more stringent selection criteria at drying off would not change the conclusion from this study (e.g., only choosing cows with an SCC of <100,000 or <150,000 cells/ml at drying off).

On a positive note, herds maintained a bulk tank SCC of <200,000 cells/ml (with the exception of one herd in one month recording an SCC = 243,000 cells/ml). This indicates that using TS only on a proportion of cows did not have a major adverse effect at the herd level, and suggests that reduced antimicrobial use is possible in Irish herds. The study will continue until the end of the current lactation.

Heifer teat seal trial

A separate study to determine the association between TS administration to heifers pre calving and infection levels in the subsequent lactation was undertaken on four separate research farms in 2015.

Four to six weeks pre calving, all heifer teats were disinfected and TS was infused in two quarters, while the remaining quarters acted as controls. Quarter level sampling was conducted at similar time points to the SDCT trial.

Teats not administered TS were between 1.99 ($P<0.05$: mid lactation) and 3.85 ($P<0.001$: first milking) times more likely to have bacteria present than those administered TS.

In approximately 6% of teats, it was impossible to administer seal. Although they were excluded from the trial, this knowledge provides important farmer information. In such a situation, it is important not to cause teat end damage.

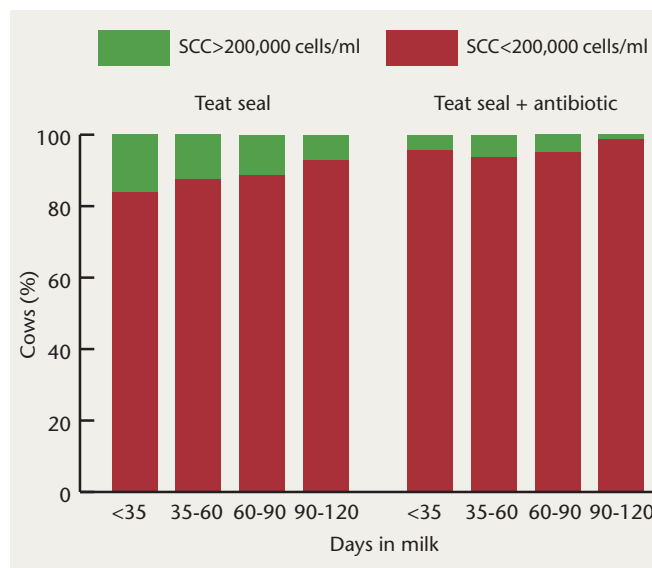


FIGURE 2: Proportion of cows in each treatment group that had an SCC recording of >200,000 cells/ml at different time points post calving.

Conclusion

Results from these studies provide a generally positive indicator that reduced antimicrobial use is possible in Irish mastitis control programmes. Further research is required to determine the appropriate balance between maintaining a high standard of udder health, and also promoting responsible antimicrobial use.

Acknowledgments

Noel Byrne and farm staff.

Authors

Aideen Kennedy

Research Officer (formerly), Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Jimmy Flynn

Laboratory Technician, Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Niamh Ryan (not pictured)

Research Officer (formerly), Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Sinéad McParland

Research Officer, Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork
Correspondence: sinead.mcparland@teagasc.ie



Piggy in the middle



TEAGASC research, as part of the OptiPig project, is looking at the effects of artificial rearing on growth, production performance and welfare of pigs.

Context

Genetic selection in pigs has resulted in increasingly large litters, with the number of piglets often exceeding the number of teats. This presents significant welfare challenges for both the sow and piglets (Rutherford *et al.*, 2013); all piglets cannot obtain their own teat for the entire lactation (as they have evolved to do) causing increased fighting between piglets at the udder, injuries to the piglets and sow, and disturbed nursing behaviour. More importantly, piglets that fail to obtain their own teat have impaired growth and a higher risk of mortality before weaning.

The OptiPig project aims to identify management strategies to improve piglets' pre-weaning growth and survival, including alleviating competition at the udder. One such strategy involves taking seven-day-old piglets from their mother and rearing them artificially in a specialised enclosure called a 'Rescue Deck®' (Figure 1). This sow is then used as a foster mother for newborn piglets from large litters (no. piglets > no. teats), so that all of these younger piglets can obtain their own teat for the full lactation. However, artificial rearing presents several challenges to the seven-day-old piglets, as they are completely deprived of maternal contact. They are fed milk replacer through cups, which they can permanently access, and obtain fresh milk by manipulating the cup's lever with their snout/mouth, in contrast to feeding in synchronised discrete bouts at the udder. Furthermore, the space available per piglet is much lower than that in the pen with their mother. The aim of this study was to establish the effects of artificial rearing (AR) on the performance and welfare of pigs from seven days old to slaughter.

Experimental set-up

The experiment was conducted on a commercial farm. At seven days old, pairs of litters (11-12 pigs) of similar weights were selected (10 replicates). One litter remained with their mother (control), and the other was transferred to a Rescue Deck® (AR) in a separate room. At approximately four weeks of age, pigs were moved to larger pens and transitioned to solid feed (weaning), and monitored until slaughter (about 113 days).

Production performance

Control and AR piglets had the same survival rate to weaning (99.2% vs 99.5%; one piglet dead in each treatment), even though AR piglets experienced a growth check relative to control piglets between transfer and day 15, and were lighter at weaning. However, pigs from both treatments had a similar average daily gain (ADG) from weaning to slaughter, and weighed the same at slaughter (approx. 113.8kg). Weaning represents the most stressful period in a pig's life. It normally involves a simultaneous change in diet, separation from the mother, and exposure to a novel environment, and consequently a severe growth check. For AR piglets these stressors were separated, and thus it is not surprising that they experienced a growth check at an earlier time than the control piglets, but caught up later in the production cycle.

Pre-weaning behaviour

Prior to weaning AR piglets were less active than control piglets, as they played and explored the environment less (Figure 2). The latter is probably related to the small size of their enclosure. Play is an important developmental feature of young animals, so low levels of play are considered indicative of reduced welfare. The AR piglets also engaged in much more belly-nosing of other piglets, an abnormal behaviour thought to reflect difficulty in coping with suddenly being prevented from suckling.

Emotional state

The pre-weaning growth lag and behaviour patterns displayed by the AR piglets suggest that their welfare was poorer than the control piglets, with potentially long-lasting effects. Thus, we investigated the emotional state of the pigs both pre and post weaning using qualitative behavioural assessment (Welfare Quality® protocol). This is a relatively new scientific method used to evaluate the expressive quality of animal behaviour and emotions. Pre weaning, control piglets had a higher score indicating a better emotional state than AR piglets (Figure 3). Inversely, at both 68 and 100 days old, AR pigs had a better emotional state. These results are in line with the production data, with the AR pigs displaying evidence of compromised welfare relative to control pigs pre weaning, but coping better with their environment as they grew older.

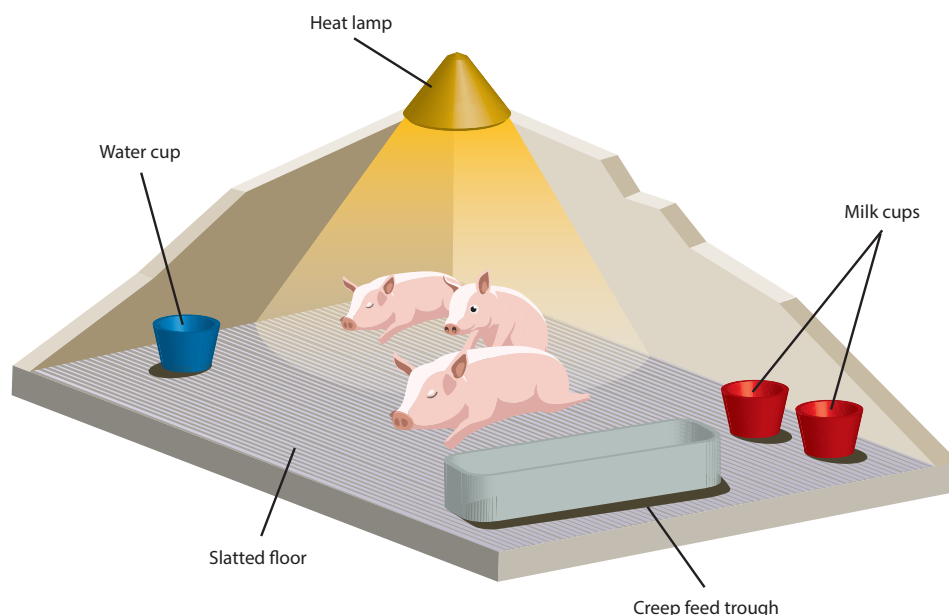


FIGURE 1: Schematic representation of the artificial rearing enclosure. About 60% of the area was covered with a canopy.

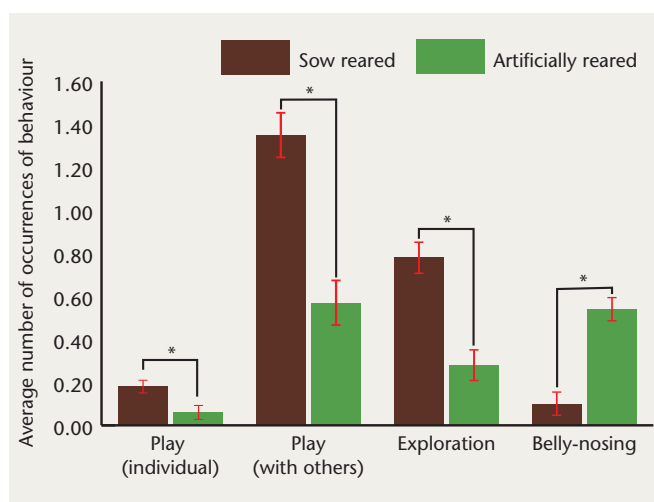


FIGURE 2: Pre-weaning behaviour of sow (i.e., control) or artificially reared piglets. *Indicates differences at $P < 0.005$.

Conclusions

- Prior to weaning AR pigs had poorer behavioural development and a growth lag compared with sow-reared pigs.
- However, AR pigs appeared to cope better than sow-reared pigs post weaning.
- There is potentially a link between emotional state and production performance in pigs.
- Artificial rearing did not appear to cause long-term poor welfare in pigs.

Acknowledgements

This study was funded by the DAFM's FIRM/RSF/CoFoRD 2013 Research Call (grant No. 13S428), under the development plan 2013.

Dr Emma Baxter (SRUC) also contributed to this work. We thank the producer who allowed us use of facilities on their farm, and the placement students who helped in collecting data.



FIGURE 3: Emotional scores attributed to sow (i.e., control) or artificially reared piglets at pre-weaning (21 days old), post-weaning 1 (68 days old) and post-weaning 2 (100 days old) periods. Higher scores represent better emotional states. *Indicates differences at $P < 0.05$.

Authors

Keelin O'Driscoll

Research officer, Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork
Correspondence: keelin.odriscoll@teagasc.ie

Laura Boyle

Senior Research Officer, Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Oceane Schmitt

Walsh Fellow, Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork



Beefing up the suckler herd

The BeefCow project, led by **TEAGASC** Grange, takes an all-Ireland approach to suckler herd fertility, looking at the many different factors affecting it and how it can be improved.

Reproductive efficiency is a major determinant of the profitability of beef suckler cow enterprises. The BeefCow project is a large Department of Agriculture, Food and the Marine- (DAFM) funded all-Ireland research programme tasked with examining key factors underpinning the reproductive efficiency of suckler beef herds. The project is led by Teagasc Grange, and involves partners at University College Dublin (UCD), the Irish Cattle Breeding Federation (ICBF), the Agri-Food and Biosciences Institute in Northern Ireland (AFBNI), and the *Irish Farmers Journal*. The principal elements of the project are discussed here.

Advancing puberty and breeding

The timing of puberty is critically important to successfully calving heifers at 24 months of age. Sexual development of the heifer is regulated by a complex interchange of biochemical messages between reproductive and brain tissues, which can be influenced by factors including breed and nutritional status. Thus, growth and body composition, particularly fat, can influence the timing of puberty. However, there is little information on appropriate replacement heifer rearing strategies to ensure early onset of breeding and calving at 24 months of age for beef breed types in Ireland.

To address this issue, a two-year study was conducted at Grange to examine the effect of post-weaning nutritional management for

different breed types on age at puberty and subsequent pregnancy rate. In total, 320 spring-born heifers purchased at seven to eight months of age from commercial herds were used.

The multidisciplinary nature of this project provides a powerful resource to enable a holistic analysis of the many factors that can influence herd fertility.

The heifers were sired by either an Angus (early-maturing) or Limousin (late-maturing) bull, and were the progeny of either dairy or beef cows. They were assigned to either a high or moderate plane of nutrition over the winter period in order to achieve average target growth rates of approximately 1kg or 0.5kg per day, respectively. The heifers were subsequently bred using AI, while at pasture, over a 12-week breeding season.

Overall, dam type did not affect age at puberty or age at first breeding, but pregnancy rate following breeding for either six or 12

weeks was higher for dairy compared to suckler-bred heifers. Heifers sired by a bull of an early-maturing breed were younger at puberty and at first breeding, and had a higher pregnancy rate at six weeks compared to those sired by a bull of a late-maturing breed, but sire breed did not influence pregnancy rate following 12 weeks of breeding. While age at first breeding was advanced for heifers on a high winter feed allowance, plane of nutrition did not affect pregnancy rate following either six or 12 weeks of breeding. Currently, the influence of nutrition during the calf-rearing phase on sexual maturation in the heifer is under investigation, and target pre-breeding growth rates are being formulated for the various breed types of interest.

Increasing use of AI

Given that only 20% of calves born annually in Irish suckler beef herds are bred using AI, there is increased interest in developing oestrous or heat synchronisation protocols that facilitate timed AI (TAI). This eliminates the requirement for heat detection, the major issue restricting the widespread usage of AI.

To this end, on-farm heat synchronisation studies were conducted by Teagasc, AFBINI and UCD in conjunction with Ceva Animal Health, and involved 74 spring- or autumn-calving suckler herds (2,205 cows). Three different synchronisation protocols were compared and all cows were subjected to a single TAI. Pregnancy rates ranged from 50-70% in these studies, with an average pregnancy rate of 55% recorded. These results were encouraging given that circa 50% of cows had not resumed normal post-partum ovarian cyclicity at the initiation of treatment. More importantly, synchronisation condensed the subsequent calving pattern such that 80% of treated cows were pregnant within the first three weeks of the breeding season (combination of TAI and repeat breedings).

Impact of pathogen and trace element status

Various endemic pathogens are frequently cited as mediators of poor fertility in beef cattle; however, there are little data available to quantify their impact on either productive and/or reproductive efficiency. To address this, almost 6,000 cows from 169 spring-calving suckler cow herds were blood sampled during the breeding season and the seroprevalence (presence of antibodies) of bovine viral diarrhoea virus (BVDV), bovine herpes virus (BHV-1), leptospirosis (*L. hardjo*) and neosporosis (*Neospora caninum*) was established.

A seroprevalence of 71, 78, 44 and 5% for leptospirosis, BVDV, infectious bovine rhinotracheitis (IBR) and neosporosis, respectively, in non-vaccinating herds was observed. Analysis of reproduction and calf performance data supplied by the ICBF showed that these pathogens had no negative impact on pregnancy rate at the end of the breeding season, subsequent calving interval, and calf mortality or liveweight performance up to 225 days. However, importantly, seroprevalence for all pathogens measured was negatively associated with the subsequent calving rate of cows diagnosed as pregnant at the end of the breeding season, suggesting a potential, though modest, negative effect on foetal mortality.

Trace elements play an important role in the health and performance of cattle and deficiencies are often suspected in cases

of poor reproductive performance, though again, there are little data to substantiate this. As part of the aforementioned epidemiological study, blood samples were also analysed for selected trace elements. Preliminary findings indicate that 15, 79 and 82% of cows are below limits considered acceptable for copper, iodine and selenium, respectively. Analyses are ongoing to determine the association of these trace elements, if any, with various reproductive, health and animal performance traits.

Whole-farm bio-economic model

The multidisciplinary nature of this project provides a powerful resource to enable a holistic analysis of the many factors that can influence herd fertility. Consequently, a comprehensive whole-farm bio-economic model is being generated, in order to more accurately inform reproductive management decisions at herd level. For example, using such an approach we have shown that while overall, seropositivity for BHV-1 (causative agent for IBR) in a spring-calving suckler herd selling weanlings in autumn had a relatively modest impact on financial performance, larger herds and those not vaccinating for the disease were found to be particularly at risk. Additionally, the impact may be greater within the context of a calf to beef system. Further such studies using this model are ongoing.

Acknowledgements

We gratefully acknowledge support from the DAFM under the Research Stimulus Fund (Project 13/S/515) and the herd owners who participated in the project. The bio-economic modelling work for this research is being conducted at Teagasc Grange by Richard Lynch as part of his PhD thesis. The valuable input of Damien Barrett

Authors

David Kenny

Principal Research Officer, Teagasc, Animal & Grassland Research and Innovation Centre, Grange, Co. Meath
Correspondence: david.kenny@teagasc.ie

Mervyn Parr

Postdoctoral Researcher, Teagasc, Animal & Grassland Research and Innovation Centre, Grange, Co. Meath

John Heslin

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

Mark McGee

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



(DAFM) to the project is also acknowledged.



Shedding light on mushroom viruses

A complex of novel viruses was discovered in commercial mushrooms in the early 2000s, which reduced the quality of this premium horticultural product across Europe. **TEAGASC**- and EU-funded research has now characterised the viruses and shown that the *Agaricus bisporus* mushroom is a model system to study fungal viromes.

Mushroom virus disease

Mushrooms are a high-value export crop, with an annual production value in Ireland in the region of €130 million. They can suffer from economically damaging viral diseases such as La France disease, which emerged in the 1960s, and which has largely disappeared from modern farms due to increased hygiene levels. It was a big surprise therefore when virus-like symptoms started to recur in the late 1990s and 2000s, but mushrooms were negative for the 35 nanometre virus particles associated with La France disease. The term Mushroom Virus X (MVX) disease was coined to cover a range of symptoms, which included widespread brown discolouration of what should be pristine white mushrooms, rendering them unmarketable (**Figure 1**). MVX has been associated with at least 26 double-stranded RNAs (dsRNAs), which are assumed to be unencapsidated viral genomes as no viral particles have been observed.

Virus-infected mushrooms analysed

The lack of knowledge on the identity and characterisation of the MVX dsRNAs has impeded our ability to develop good diagnostics for the industry, as well as to understand their role and function within the mushroom mycelium. RNA was isolated from ten samples of mushrooms from different sources and with different viral symptoms. Viral contigs were *de novo* assembled, sequenced and classified to shed light on their relatedness and phylogeny, with reference to known virus families. Differences in viral number, titre and composition were identified, suggesting different host adaptations and viral lifestyle transitions.

Eighteen mushroom viruses identified

Next-generation sequencing of the RNA extracted from the mushroom samples revealed 30 distinct RNA contigs not found in the *Agaricus bisporus* genome, which ranged in size from 0.5-14.5kb. Eighteen of

them contained an RNA-dependent RNA polymerase (RdRp) domain, characteristic of fungal viruses, and we propose that these represent 18 distinct viruses (**Figure 2**). A nomenclature is proposed of *Agaricus bisporus* Virus N (N replaced by a sequential number). Sixteen of the viruses had a monopartite structure of a single RNA molecule while two viruses were segmented viruses: AbV6 consisted of two separate contigs, while AbV16 contained four separate contigs. AbV16 is the fungal virus associated with the brown mushroom symptoms seen in crops affected by MVX. The RdRps of the 18 viruses have closest amino acid homology to a diverse array of positive sense single-stranded RNA viral orders/families/genera (ss(+)RNA): *Hypoviridae*, *Tymovirales* (*Betaflexiviridae* and *Gammalflexiviridae*), *Narnaviridae*, *Barnaviridae*, *Bromoviridae*, *Endornaviridae*, *Virgaviridae*, and the unassigned genera *Benyvirus* and *Ourmiavirus*. The majority of the viruses are only distantly related to known viruses and, accordingly, new phylogenies are proposed. Phylogenetic analysis of the RdRp domain of the AbV16 virus places it into its own unique clade, distinctive from all previously described viral groupings. Therefore, we propose a new viral family, which has been named *Ambsetviridae*. Bioinformatic analysis of existing RNA sequence databases reveals the existence of other members of the *Ambsetviridae* family from the plant and fungal kingdoms.

Viral interactions

Only AbV16 has been directly correlated with the adverse browning symptoms displayed by mushrooms and it would appear that the other viruses may be benign. There is evidence that AbV16 can be 'lost' during crop cultivation while other viruses persist, as individual mushrooms attached to the same mycelial network can manifest different levels of AbV16. It is interesting to speculate that within the mycelial network there is a dynamic interaction (competition?) between the different viruses. We have observed changing patterns of viral composition from



FIGURE 1: Poor-quality discoloured mushrooms.

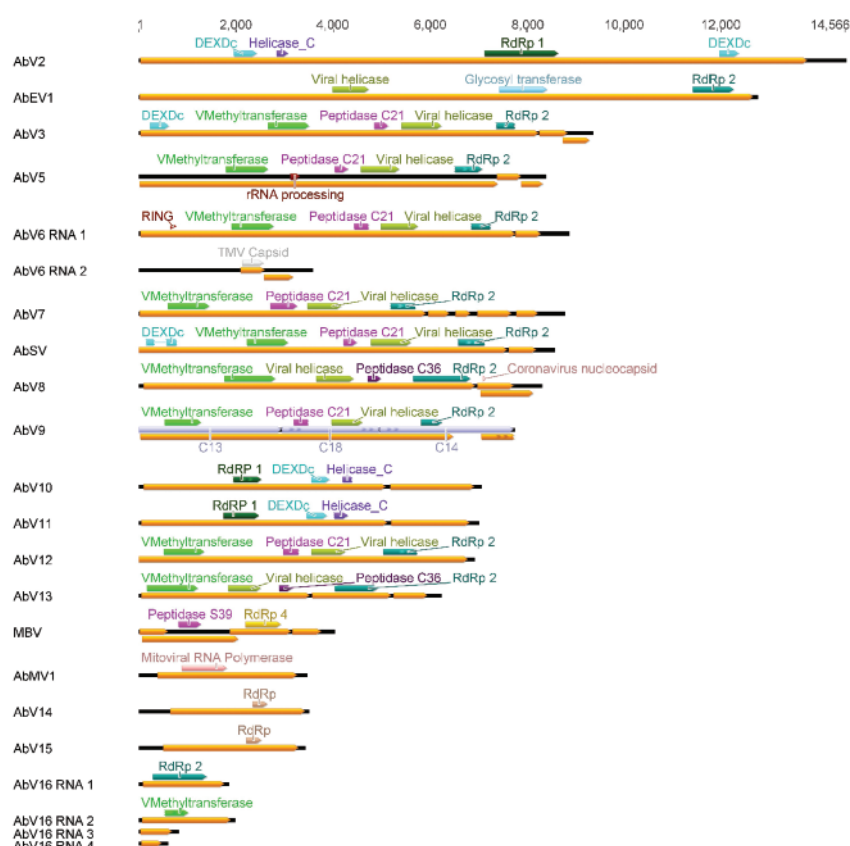


FIGURE 2: Genome organisation and protein coding potential of the 18 viruses identified in the MVX complex (from Deakin et al., 2017).

sample to sample, with a consequential changing pattern of cap browning symptoms when AbV16 titre increases or decreases. This hypothesis goes some way towards explaining the variable pattern of symptom expression that has been observed in commercial crops for the past 20 years. It may be that one or more of the other viruses can outcompete or suppress AbV16 within the mycelial network, something which could be useful from a virus resistance perspective. Current work is exploring this hypothesis.

The presence of so many viruses in a single organism is relatively rare and thus *Agaricus bisporus* is an ideal model organism to study viral-viral and viral-host interactions of a fungal virome. Full details of this work can be found in the scientific publication of the results (Deakin, Dobbs *et al.*, 2017).

Significance for the mushroom sector

The genetic sequence and identity of 18 new fungal viruses that can infect commercial mushroom crops is now known. The presence of these viruses can be detected by molecular methods in a variety of mushroom material, such as mushrooms and compost, while mushroom breeders can screen fungal germ plasm for viruses during strain development.

Reference

Deakin, G., Dobbs, E., Bennett, J., Jones, I.M., Grogan, H.M. and Burton, K.S. (2017). 'Multiple viral infections in *Agaricus bisporus* – Characterisation of 18 unique RNA viruses and 8 ORFans identified by deep sequencing.' *Scientific Reports*, 7, Article number: 2469. Available from: <http://www.nature.com/articles/s41598-017-01592-9>.

Acknowledgements

Julie Bennett of NIAB EMR, UK, and Ian Jones, University of Reading, UK, also contributed to this work. The research leading to these results has received funding from Teagasc and from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement No. 286836 (MushTV).

Authors

Helen Grogan

Senior Research Officer, Horticulture Development Department, Teagasc Research Centre, Ashtown, Dublin 15
Correspondence: helen.grogan@teagasc.ie

Greg Deakin

Teagasc Walsh Fellow

Edward Dobbs

Research Scientist, NIAB EMR, East Malling Research, Kent, UK

Kerry Burton

Principal Research Scientist, NIAB EMR, East Malling Research, Kent, UK



Nitrous oxide from ruminant excreta

Irish agriculture creates 90% of national N₂O emissions, much of which come from dung and urine. **TEAGASC** researchers are looking at quantifying N₂O emissions, and assessing mitigation strategies for this potent greenhouse gas.

The pasture-based livestock systems dominating Irish agriculture are inherently 'leaky' in their nitrogen (N) use efficiency, with less than 30% of applied N recovered in final products – meat and dairy. Ruminant livestock excrete 70-95% of their N intake onto pasture as dung and urine.

These excreta patches, in particular urine, are an important source of the potent greenhouse gas (GHG) nitrous oxide (N₂O). As much as 41% of N₂O produced from Irish agriculture comes from urine and dung deposited by grazing animals. However, there is large uncertainty around this figure.

Ireland has committed to reducing national GHG emissions by 20% by 2020 under the EU Energy and Climate Package. Achieving these targets and realising the opportunities for growth identified in the Food Wise 2025 report pose a significant challenge for Irish agriculture, which accounts for 90% of national N₂O emissions. Therefore, accurate accounting and targeted mitigation of N₂O from excreta at pasture is urgently required.

Aims

The aims of this research were:

- to quantify N₂O emissions from urine and dung deposited to pasture by grazing animals;
- to examine the interactive effects of synthetic N fertiliser applied to urine and dung patches in pasture; and,
- to assess potential mitigation of N₂O emissions from urine patches by manipulating urine composition.

Developing nitrous oxide emission factors for excreta deposited on pasture

Currently, Ireland uses the Intergovernmental Panel on Climate Change (IPCC) default emission factor (EF) of 2% to estimate excreta-derived N₂O, meaning that 2% of N in the excreta patches is estimated to be lost as N₂O.

However, N₂O can vary greatly depending on the type of excreta (dung or urine), soil type and timing of application. During a recent project, N₂O was measured from urine and dung in spring, summer and autumn on well-drained, moderately drained and imperfectly

drained pasture soils. Measurements took place for 12 months following excreta application using a recognised static chamber method.

The average N₂O EF was 0.31% and 1.18% for cattle dung and urine, respectively. N₂O loss was driven by rainfall, temperature and soil moisture, with highest N₂O EFs in autumn and from the imperfectly drained soil (**Figure 1**). These N₂O EFs are lower than the current default value used in Ireland's national GHG inventory and highlight that N₂O emissions from animal excreta deposited on pasture by grazing animals in Ireland may be overestimated.

Ireland has committed to reducing national GHG emissions by 20% by 2020 under the EU Energy and Climate Package.

Interactive effects of synthetic N fertiliser with excreta deposited on pasture

In intensively managed grazing systems, mineral fertiliser is typically spread shortly after grazing to promote regrowth between rotational grazing cycles. Consequently, annually, up to approximately one-fifth of this fertiliser is applied to urine patches.

However, in the national GHG inventory, N₂O emissions from these N sources are calculated separately and then added together. An experiment was conducted to investigate the effect on N₂O and associated N₂O EF of fertilising existing urine patches using a variety of synthetic fertilisers, and to examine the effect of how emissions from these areas of overlapping N loading are calculated in the national GHG inventory.

N sources applied separately and measured N₂O losses added together were called 'disaggregated' and 're-aggregated', respectively, versus N sources applied together called 'aggregated'. Application of fertiliser to urine patches did not significantly increase

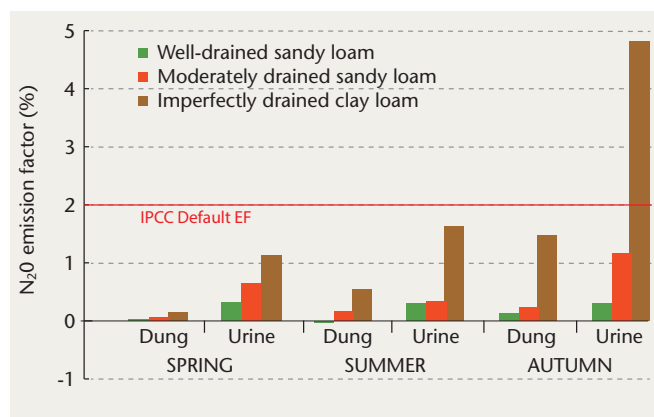


FIGURE 1: Direct nitrous oxide emission factors for different excreta sources, over three seasons and applied to three different soils.

either the N_2O emissions or the N_2O EF in comparison to urine and fertiliser applied separately. However, there was a consistent trend for 20% underestimation of N_2O loss calculated this way, suggesting uncertainty in the national GHG inventory.

Mitigation of nitrous oxide emissions from urine

Previous laboratory studies shed light on the potential of mitigating N_2O losses from urine patches by changing urine composition through dietary amendments (incremental additions of hippuric acid (HA) and/or benzoic acid (BA)). This experiment investigated the effect of elevating concentration of these minor urine constituents on N_2O emission *in situ* under soil conditions conducive to denitrification. However, manipulation of ruminant urine by adding HA and/or BA was found to have no effect on N_2O emissions. Although promising results were observed in the laboratory studies, these acids were not effective at mitigating N_2O loss *in situ* (Figure 2).

Conclusions and future research

Country-specific N_2O EFs for ruminant excreta will feed directly into the refinement of Ireland's national GHG inventory. This will, in future, allow disaggregation of EFs between types of excreta, soil type and timing of deposition. More research is needed into areas of overlapping fertiliser and excreta N loading and mitigation options for urine-derived N_2O . Although manipulation of HA and BA concentration in urine had no mitigating effect, other urine manipulations, such as reducing N content or inclusion of novel inhibitory products, might prove successful.

Acknowledgements

This research was funded by the Department of Agriculture, Food and the Marine (RSF10/RD/SC/716 and 11S138).

Further reading

Krol, D.J., Minet, E., Forrester, P.J., Lanigan, G.J., Mathieu, O. and Richards K.G. (2017). 'The interactive effects of various nitrogen fertiliser formulations applied to urine patches on nitrous oxide

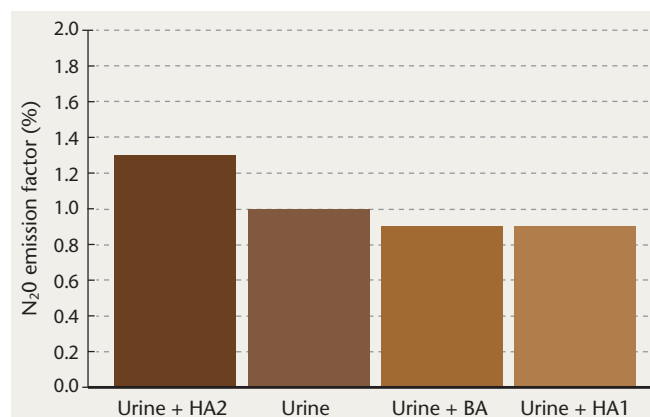


FIGURE 2: Direct nitrous oxide emission factors from urine with and without amendments.

emissions in grassland.' *The Irish Journal of Food and Agricultural Science*, 56: 54-64.

Krol, D.J., Carolan, R., Minet, E., McGeough, K.L., Watson, C.J., Forrester, P.J. *et al.* (2016). 'Improving and disaggregating N_2O emission factors for ruminant excreta on temperate pasture soils.' *Science of the Total Environment*, 568: 327-338.

Krol, D.J., Forrester, P.J., Lanigan, G.J. and Richards K.G. (2015). 'In situ N_2O emissions are not mitigated by hippuric and benzoic acids under denitrifying conditions.' *Science of the Total Environment*, 511: 362-368.

Authors

Dominika Krol

Research Officer, Teagasc Crops, Environment and Land Use Research Programme, Johnstown Castle, Co. Wexford
Correspondence: dominika.krol@teagasc.ie

Patrick Forrester

Research Officer, Teagasc Crops, Environment and Land Use Research Programme, Johnstown Castle, Co. Wexford

Gary Lanigan

Principal Research Officer, Teagasc Crops, Environment and Land Use Research Programme, Johnstown Castle, Co. Wexford

Karl Richards

Principal Research Officer and Head of Environment, Soils and Land Use Department, Teagasc Crops, Environment and Land Use Research Programme, Johnstown Castle, Co. Wexford





Thinning for profit

New **TEAGASC** research suggests that forest thinning should focus on increased removal of inferior quality trees earlier in the forest life cycle, to focus on trees with greater potential to reach construction grade timber.

Background

While trees are initially planted in forests at approximately 2,500 stems per hectare, competition and natural selection reduces the number of trees over time. Taller, vigorous trees are better at competing for light, moisture and nutrients, while the smaller, weaker trees eventually die. Thinning is the practice of artificially removing inferior quality trees to concentrate timber production on trees with superior form for the achievement of high-value construction-grade timber. As many farmers have planted forest crops, thinning represents an opportunity to increase the production of more valuable timber products. Current research in Teagasc investigates the impact of thinning on crop development, timber quality and profitability, which aims to support best practice development in the sector. The research suggests that intensifying thinning practice will ensure increased mobilisation of value-added timber products from the sector.

An assessment of log straightness of the remaining crop was also carried out to determine if thinning improved the quality of the remaining trees.

Experimental study

A thinning trial in a highly productive Sitka spruce crop in Frenchpark, Co. Roscommon, was monitored over two thinning cycles, which took

place over a six-year period from 2010 to 2016. Four different thinning treatments were assigned: no thinning (control); light (retain 80% of the control); medium (retain 68% of the control); and, heavy thinning (retain 62% of the control). The first thinning operation emphasised the removal of dead, dying and inferior quality stems with the objective of improving the quality of the remaining crop. The second thinning operation was focused on the removal of inferior quality competing stems. The gross volume removed increased with the intensity of thinning, with 91m³/ha being removed in the light thinning, 123m³/ha in the medium thinning, and 135m³/ha in the heavy thinning over the two thinning operations. A proportion of gross volume from thinning is composed of stumps and tree tops, and the net volume is available for cutting into wood products. Removed trees were cut into pulpwood (smaller, poor quality stems) and pallet wood (larger, better quality stems for pallets) depending on quality and length of trees. Based on the sale of timber, pulpwood commanded a price of €6/m³ and pallet wood a price of €18/m³ in the forest; no sawlog was produced in either thinning. An assessment of log straightness of the remaining crop was also carried out to determine if thinning improved the quality of the remaining trees.

Results

At first thinning, over 60% of volume removed was pulpwood, with increases in pulpwood production with greater intensity of thinning; little difference between pallet wood was apparent between treatments. Timber revenues from first thinning ranged from €475/ha for the light thinning, to €564/ha for the medium thinning and €616/ha for the heavy thinning. At second thinning, the amount of pallet wood removed

Table 1: Details of volume, timber assortments and revenue generated after two thinning cycles in the Frenchpark thinning trial.

Treatment	Age (yrs)	Stems (ha)	Total vol. (m ³ /ha)	Standing vol. (m ³ /ha)	Thinned vol. (m ³ /ha)	Pulp (m ³ /ha)	Pallet (m ³ /ha)	Combined revenue (€/ha)
Unthinned	21	1,990	452	452	0	0	0	0
Grade B	21	1,163	477	386	91	53	27	809
Grade C	21	938	461	338	123	56	51	1,255
Grade D	21	791	446	311	135	63	55	1,364



FIGURE 1: Increased growing space following thinning facilitates increased growth.

increased with thinning intensity, with yield increasing from 29% of total volume in the light thinning, to 59% in the medium thinning, and 65% in the heavy thinning treatment. Timber revenues for second thinning ranged from €334/ha for the light thinning, to €691/ha for the medium thinning and €748/ha for the heavy thinning. Total revenue generated from the two thinning operations was greatest in the heavy thinning at €1,364/ha, with €1,255/ha for medium and €809/ha for the light thinning. No revenue was generated for the unthinned control plots (Table 1). There is no indication that heavy thinning is negatively impacting on volume production of the crop, with only a modest decrease (1% difference) between the control and the heavy thinning. Thinning has facilitated the development of larger trees as a result of increased growing space, with the average trees in the heavy thinning nearly twice the volume (0.4m³) of the trees in the control treatment (0.23m³) (Figure 1). Thinning has greatly enhanced the quality of the remaining trees, with the greatest amount of straight logs apparent in the heavy thinning treatment (Figure 2).

Conclusion

Where possible, thinning should be considered earlier in the life cycle of a forest and the adoption of robust thinning practice with increased

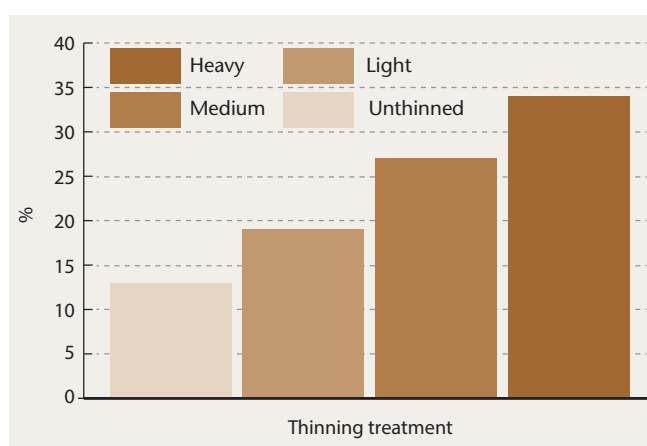


FIGURE 2: Volume of straight logs (>5m) according to thinning treatment.

removal of inferior quality trees offers the best results. Options to increase the intensity of thinning may provide for increased revenues at first and second thinning, especially when compared to a no thinning regime. Timber quality can be significantly enhanced with a greater removal of inferior trees, with an increase in the yield of straight logs. The potential to reduce rotation times exists, as trees have increased growing space to reach merchantable size quicker. Further research will evaluate the impact of thinning on the structural properties of timber.

Authors

Niall Farrelly

Senior Research Officer, Forestry Development Department, Teagasc, Athenry, Co. Galway

Correspondence: niall.farrelly@teagasc.ie





Improving meat fatty acid profile

Researchers at **TEAGASC**, in collaboration with Nanovex Biotechnologies, Spain, have been looking at the application of nanoencapsulation and ultrasound technology to improve the nutritional quality of meat by modifying its fatty acid profile.

Pork is a rich source of proteins and contains a number of bioactive molecules. However, pork also contains high levels of lipids, which have been a topic of discussion for meat consumers due to their associated health implications. Relationships between dietary fat intake and incidence of various lifestyle disorders, including cardiovascular diseases, are well established, and several health agencies have specific guidelines in this regard. Several strategies have been employed to improve the nutritional value of meat, for example: the reduction of caloric value and fat content; reduction of cholesterol content; increase of amino acid quality; enrichment with minerals, vitamins and antioxidants; reduction of sodium, nitrite and phosphate contents; or, enhancement of fatty acid profile, as in this research. Research studies carried out at Teagasc showed that the incorporation of encapsulated polyunsaturated omega-3 fatty acids into meat can enhance the fatty acid profile of pork meat.

Encapsulation technology

Encapsulation of bioactive food ingredients provides a barrier and protection from unfavourable processing conditions while preserving the nutritional properties of the ingredient. In recent decades, encapsulation technology has shown several potential applications in the pharmaceutical and functional food industries. Encapsulation involves packing the target ingredient within a wall of material to form capsules.

Several techniques are available in order to encapsulate targeted fatty acids, the most popularly employed approaches being coacervation, spray drying, spray chilling, extrusion coating and liposome entrapment by thin film hydration (TFH). Incorporation of

microencapsulated oils has been carried out in a range of food matrices for various potential health benefits; in this particular work, food-grade materials were employed. However, incorporation of encapsulated ingredients in solid foods, e.g., meat, is challenging compared to liquid foods, since diffusion rates are low and the oil is not effectively dispersed into a solid food matrix. Among several techniques investigated to date, ultrasound has shown its potential for use in the assisted diffusion of a number of ingredients within food matrices. For example, the application of power ultrasound can enhance sodium chloride (NaCl) diffusion rates into the meat, making the process faster and resulting in a more homogeneous product. This technique has resulted in an improvement of brining processes, for example.

Relationships between dietary fat intake and incidence of various lifestyle disorders, including cardiovascular diseases, are well established, and several health agencies have specific guidelines in this regard.

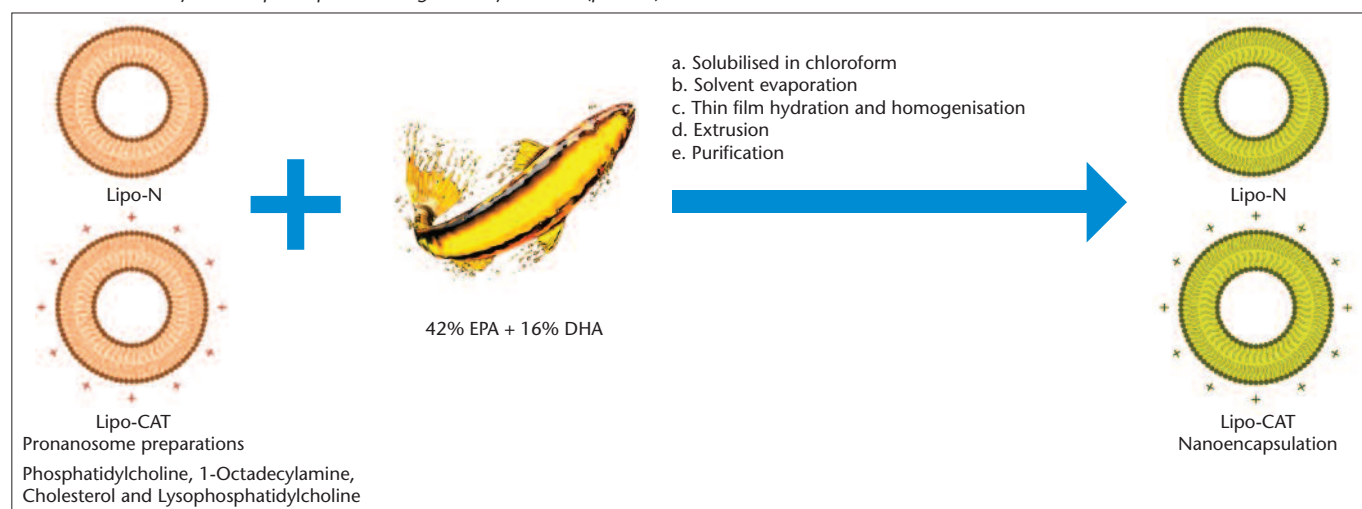
Development of nanovesicles

Fish oil, a rich source of omega-3 fatty acids (eicosapentaenoic acid or EPA (42%) and docosahexaenoic acid or DHA (16%)), was encapsulated

Table 1: Characteristics of nanovesicles based on their formulation.

Nanovesicles	Average size (nm)	Polidispersity index	Zeta potential (mV)	Particle concentration (vesicles/mL)
Lipo-N	352.8±8.5 ^a	0.266±0.037 ^a	14.4±0.1 ^b	5.8 x 10 ^{12a}
Lipo-Cat	345.9±5.1 ^a	0.319±0.010 ^a	51.3±1.0 ^a	7.2 x 10 ^{12a}

^{a,b}Values followed by same superscript are not significantly different ($p < 0.05$).

**FIGURE 1: Preparation of nanovesicles.**

into nanovesicles using Pronanosome Lipo-N and Pronanosome Lipo-Cat formulations by means of TFH (Figure 1). The characteristics of the nanovesicles developed are shown in Table 1.

Incorporation of fatty acids

A study carried out by Teagasc has shown that ultrasound treatments of pork meat cubes submerged in the corresponding nanovesicle suspension in an ultrasonic bath system can improve diffusion of nanovesicles into pork meat. Application of ultrasound at 25kHz for 60 minutes significantly increased the level of omega-3 fatty acids in the meat matrix, regardless of the nanovesicle formulation. This effect is mainly ascribed to the increased amount of EPA and DHA incorporated with the nanovesicles. The content of these two fatty acids was primarily affected by ultrasound treatment and time. Longer treatments significantly increased ($p < 0.05$) the amount of omega-3 fatty acids present in the final product. In general terms, all long chain polyunsaturated fatty acids (PUFAs), which are present in the encapsulated fish oil, experienced a positive effect following ultrasound treatment. These results indicate that ultrasound enhanced the mass transfer of encapsulated oil into the meat samples. Therefore, a positive effect on the fatty acid profile of pork meat was promoted, since the ratio between saturated and polyunsaturated fatty acids was favourably modified.

Conclusions

A combination of two novel technologies, namely nanoencapsulation and ultrasound, has been applied in order to improve the lipid profile of pork meat. This study has demonstrated the positive effect that

ultrasound application, when combined with encapsulated fish oil, had in increasing the amount of healthy fatty acids in pork meat.

Further reading

Ojha, K.S., Perussello, C.A., Garcia, C.A., Kerry, J.P., Pando, D. and Tiwari, B.K. (2017). 'Ultrasonic-assisted incorporation of nano-encapsulated omega-3 fatty acids to enhance the fatty acid profile of pork meat.' *Meat Science*, 132: 99-106.

Authors

Shikha Ojha

Walsh Fellow, Teagasc Food Research Centre, Ashtown, Dublin 15
Correspondence: shikha.ojha@teagasc.ie

Carlos Alvarez

Research Officer, Teagasc Food Research Centre, Ashtown, Dublin 15

Brijesh K. Tiwari

Principal Research Officer, Teagasc Food Research Centre, Ashtown, Dublin 15





Membrane filtration for consistent cheese

Research at **TEAGASC** Moorepark is comparing methods of membrane filtration in milk protein standardisation in order to improve cheese quality.

Introduction

World cheese production has grown at an average rate of 1.9% per annum since 2010, and amounted to ~23 million tonnes in 2015 (IDF, 2016). Irish cheese production grew from 172,000 to 207,000 tonnes in the same period, and utilises ~31% of total milk produced. The increased demand for cheese is driven by a rise in global population, an increase in living standards, wide availability of different varieties, and adaptability of cheese to modern food service practices. Simultaneously, the requirement for more consistent quality, nutrient density (e.g., levels of fat, salt, lactose) and functionality has increased. Such demand is driven by higher consumer expectations, health agencies, legislators, and suppliers and retailers in pursuit of greater market share. Nevertheless, inconsistency does occur in cheese composition and quality, a major cause being seasonal variation in milk composition in conjunction with the use of standard operating procedures (SOPs) that do not account for such seasonal variation. In particular, variation in the concentrations of milk protein and casein over the cheese-making season (e.g., from 3.3–4.2%, and 2.5–3.2%, respectively) are conducive to changes in key compositional parameters such as moisture, pH and salt-in-moisture, which in turn impact on ripening and quality of cheese.

Standardisation of milk for cheese making

It is now almost universal practice in modern cheese manufacture to standardise the protein-to-fat ratio of the cheese milk (typically by removal or addition of cream) to a target value, the magnitude of which differs according to cheese variety and the brand of cheese being manufactured. The use of curd washing to standardise the content of lactose, and hence lactic acid, is applied in the manufacture of Dutch-style cheeses such as Gouda and Leerdammer to ensure consistent pH and texture in the final cheese; the degree of washing is proportional to the lactose content of the cheese milk. Standardisation

of milk protein content to a target value (e.g., 4.5%) is now widely practised in many countries such as the USA, Australia, New Zealand and parts of Europe, to ensure cheeses with consistent composition, texture, flavour and functionality. Despite the relatively large seasonal variation in milk composition in Ireland, standardisation of milk protein is not widely practised.

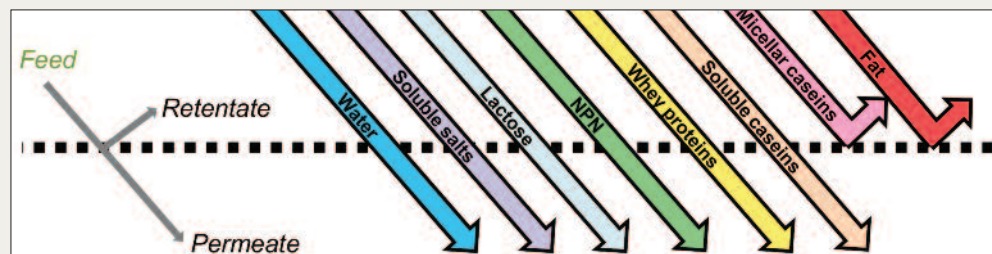
The use of membrane filtration to standardise milk protein content

Membrane filtration is a pressure-driven separation process, which allows for selective retention and concentration of some components from the feed stream. The membrane porosity determines which components are retained and concentrated as a retentate, and which migrate through the membrane as permeate. Ultrafiltration (UF) and microfiltration (MF) are membrane processes applied during milk processing to concentrate total milk protein (casein and whey protein) or casein, respectively.

The main difference between UF and MF is that whey proteins are retained during UF and permeated during MF (**Figure 1**). The migration of whey proteins during MF results in a whey protein-enriched permeate stream, frequently referred to as 'ideal whey', because, unlike cheese whey, it is not contaminated by other milk components such as colloidal milk salts, casein macropeptide, fat, cheese starter cultures or colourants. The 'ideal whey' can be used to make high-quality whey protein products such as whey protein isolates and whey protein fractions (e.g., α -lactalbumin, lactoferrin), which may be used in an array of high-end applications such as nutritional, sports and therapeutic beverages.

Low concentration factor membrane ultrafiltration (LCFUF) or microfiltration (LCFMF) refers to ultrafiltration or microfiltration processing where the protein or casein content of the milk is increased by a factor of ~1.4–1.8, e.g., from a typical protein content of 3.3–3.6%

Microfiltration (MF)



Ultrafiltration (UF)



■■■■■ Membrane
Feed: whole milk or skim milk

FIGURE 1: Partition of milk components by microfiltration (MF) and ultrafiltration (UF).

in the raw milk to a target value of 4.5-5.0% in the protein-standardised milk. Milk protein standardisation provides greater compositional and quality consistency, especially in large modern plants with milk volumes of 1-3m litres of milk per day and with minimal intervention of developed SOPs to ensure smooth plant running and consistent throughput. Other potential benefits of milk protein standardisation include higher plant throughput and a lower cheese vat capacity. The choice between LCFUF and LCFMF for milk protein standardisation depends on a variety of factors, including the impact on cheese quality, site processing capability, product mix, required capital expenditure for membrane plant (higher for MF), and operating costs.

Moorepark study

A study entitled 'Optimisation of milk protein standardisation for improving the quality (texture and flavour) of cheese from a seasonal milk supply' is currently being undertaken at Teagasc Food Research Centre, Moorepark, and funded through the Dairy Processing Technology Centre. The project is on low-concentration membrane filtration and focuses specifically on:

- a review of the published literature on the state of the art of LCFUF and LCFMF for milk protein standardisation for cheese;
- the effect of warm and cold LCFUF or LCFMF on potential permeation of casein and minerals (e.g., calcium); and,
- the comparative effects of LCFUF and LCFMF on various aspects of Cheddar cheese, including composition, fat and protein recovery, yield, and biochemical and textural changes during maturation.

The cheeses are made using both a Teagasc standardised operating procedure and a non-standardised operating procedure, where the former involves adding starter culture and coagulant pro rata with protein content in the standardised milk, cutting the gel at a defined strength, and undertaking different steps such as setting and whey

drainage at defined pH values, while the latter primarily involves undertaking cheese making processing steps at defined time points. While the study is ongoing, preliminary results indicate that membrane type and operating temperature affect mineral and protein permeation. However, membrane type (LCFMF, LCFUF) had little effect on cheese composition or manufacturing efficiency.

Acknowledgement

This work was supported by the Irish State through funding from the Technology Centres programme – Grant Number TC/2014/0016.

Reference

International Dairy Federation. (2016). 'The World Dairy Situation 2016'. Bulletin of the International Dairy Federation 485/2016.

Authors

Kevany Soodam

Postdoctoral Researcher, Food Chemistry and Technology Department, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork, and Dairy Processing Technology Centre (DPTC), Ireland
Correspondence: kevany.soodam@teagasc.ie

Timothy P. Guinee

Principal Research Officer, Food Chemistry and Technology Department, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork



The status quo on small farms

A snapshot of the sustainability of small farming in Ireland using the **TEAGASC** National Farm Survey.



A special survey of small farms conducted through the Teagasc National Farm Survey (NFS) in 2015 examined the economic, social and environmental sustainability of small farms in Ireland. Small farms, defined as those producing a standard output of €8,000 per year or less (the equivalent of 14 suckler cows) are not normally represented by the Teagasc NFS in its annual income report and hence very little is known about their circumstances. Although over one-third of all farms in Ireland (52,000 farms) are classified as small, they have a low intensity of production and collectively contribute less than 5% of all agricultural output in the State. Despite this, they occupy 16% of the total farmland area of the country, with two-thirds of them situated in the Border, Midland and West regions.

The small farms survey was undertaken on cattle and sheep farms, as these are the predominant production systems on these farms. Results from the survey are compared to a subsample of the regular Teagasc NFS cattle and sheep farms in 2015 (referred to here as larger farms since their standard output exceeds €8,000). Family farm income (FFI) is the principal economic measure produced by the Teagasc NFS and represents the return from farming to the farm family for their labour, land and capital. This measure does not include the non-farm component of farm household income. In 2015, small farms typically earned farm incomes of less than €3,000 with three-quarters of them reporting an FFI of less than €5,000. Clearly, an adjustment must be made for the difference in farm size across the two groups, with the

average utilised land area of small farms being 14 hectares in 2015, compared to 40 hectares on the larger farms. **Table 1** illustrates that small farms typically produce less output per hectare and have higher costs per unit of output. The level of direct payments per hectare is very similar, but larger farms are more efficient, with costs consuming 68% of output on larger farms compared to 74% of output on small farms. This seems to be driven by the relatively high overhead costs on the small farms. There is a very significant income differential of €163 per hectare between the two groups, with larger farms producing an income per hectare 80% higher than small farms.

Given the extremely low levels of farm income, it is not surprising that a large proportion of small farms (88%) have some alternative form of income. In terms of the sources of that income, either the farmer or spouse had an off-farm job in almost half of all households. Given the slightly older age profile on small farms (one-third of all farmers are aged over 65), a relatively high proportion (39%) are in receipt of pensions.

Finally, an overview of the economic viability of small farms is contained in **Figure 1**. Based on the work of Frawley and Commins (1996), a farm is defined as being economically viable if it can remunerate family labour at the average agricultural wage, and provide a 5% return on non-land assets. Two further categories exist. The first are farms deemed 'sustainable' (not economically viable based on farm income alone, but due to the presence of another income earned from an off-farm job). The final group is

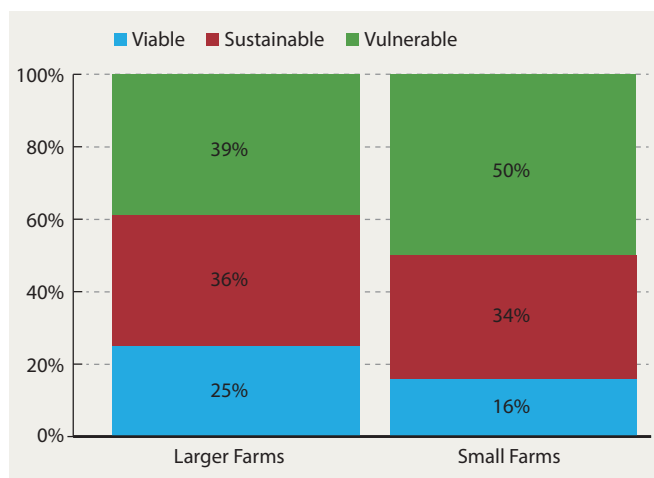


FIGURE 1: Viability of cattle and sheep farms 2015. (Source: Teagasc National Farm Survey.)

deemed vulnerable if the farm is not viable and there is no off-farm income present in the household.

Clearly, the economic situation on small farms is worrying, with only 16% classed as viable in 2015. Although more than one-third of farm households are classed as sustainable, the proportion of small farms classified as vulnerable is extremely high at 50%. In other words, half of all small farms are not economically viable businesses and neither the farmer nor the spouse works off the farm.

Given the slightly older age profile on small farms (one-third of all farmers are aged over 65), a relatively high proportion (39%) are in receipt of pensions.

Future concerns

Given the low levels of economic sustainability in these small farm households, one would expect that a major change is about to occur: that these farms will cease to exist, more of them will go part-time, or they will diversify. However, the survey found that little change is expected. Just 15% of small farm households would consider leasing their land. Of those that are not already working off the farm just 7% are looking for employment, although age may be a limiting factor for many. Just 4% would consider planting forestry as a viable alternative. As small farms receive over €200 million each year from the Basic Payment Scheme, there is an ongoing debate about the future of these farms and the role they play in the rural economy. Clearly, these small farms plan to continue in production and for many this is good news. The social and economic presence that these farmers provide in rural areas that are often bereft of

Table 1: Average family farm income per hectare – cattle and sheep farms, 2015.

	Larger farms	Small farms
Gross output	1,137	801
(of which direct payments)	373	387
Total costs	769	596
(of which direct costs)	371	233
(of which overheads)	398	363
Family farm income	368	205

Source: Teagasc National Farm Survey.

other economic activity is essential. The upcoming CAP reform and the future of direct payments, which are vital to this group of farms, will be the ultimate deciding factor in their long-term sustainability.

Full report available at:

<https://www.teagasc.ie/publications/2017/small-farms-survey.php>.

Acknowledgements

Many thanks to NFS staff involved in the collection and validation of the data: A. Curley, J. Colgan, L. Delaney, P. Harnett, P. Healy and J. Robinson, and to M. Moloney for the administration of the survey.

Authors

Emma Dillon

Agricultural Economics and Farm Surveys Department, Rural Economy Development Programme, Teagasc, Athenry, Co. Galway
Correspondence: Emma.Dillon@teagasc.ie

Thia Hennessy

Professor and Head of Food Business and Development, University College Cork

Brian Moran

Agricultural Economics and Farm Surveys Department, Rural Economy Development Programme, Teagasc, Athenry, Co. Galway

John Lennon

Agricultural Economics and Farm Surveys Department, Rural Economy Development Programme, Teagasc, Athenry, Co. Galway





The sweet spot for health and taste

Research has been undertaken at **TEAGASC** in conjunction with UCC to determine how the healthier food choice can be made not only the easier choice but the tastier choice for consumers.

Some researchers report that we make over 200 food decisions every day, highlighting that eating and drinking are among the most frequent of daily human behaviours. In order to understand or try to influence food choice decisions and behaviours, attitudes and motivations underpinning such behaviours must be explored and understood. Previous research has shown that the development of food-based dietary guidelines to positively influence food choice should be culturally appropriate and based on existing food behaviours. However, these guidelines frequently fail to fully account for the impact of the most salient attitudes and motivations influencing food consumption behaviour. The aim of this research was to determine the impact of food choice attitudes and motivations on dietary behaviour and to demonstrate how this evidence can be used to inform dietary guidelines as well as new product development. Data from the National Adult Nutrition Survey (NANS) were used. NANS is an extensive study on the food and beverage consumption of Irish adults, including anthropometric measurements, socio-demographic and lifestyle data, and physical activity. Additionally, as part of the survey, dietary attitudes and motivations were measured using a food choice questionnaire.

Motivations, attitudes and behaviour

Analysis of motivations and attitudes alongside the behavioural measure of food intake has shown that taste is the most

important food choice motive for consumers, followed by health and nutrition. Taste was a more important food choice motivation for men compared to women and for younger compared to older consumers. In addition, those who rank taste and other motivations such as cost and convenience high in importance have different behaviours in relation to the amount of foods consumed compared to those who assign a higher ranking of importance to health and nutrition. Consumers motivated by health, for example, consumed higher amounts of dairy, cereal, and fruit and vegetables compared to those who placed lower importance on health.

Table 1 shows the differences in energy intake, fat as a percentage of energy, body mass index (BMI), and fruit and vegetable intake across the ranking of various motivations. Fat intakes (as a percentage of overall energy consumed) were higher in those who place high importance on taste. BMI was lower and achievement of dietary guidelines such as fruit and vegetable consumption was higher in those placing a higher ranking importance on nutrition. Ranking cost highly as a motivation for food choice was associated with a higher BMI and lower fruit and vegetable consumption, and overall lower compliance with dietary guidelines. Younger consumers and men were motivated to choose foods based on the sensory (taste) and convenience attributes of the foods.

Table 1: Food choice motives, consumption patterns and BMI in Irish consumers.

	Energy intake (kcal/day)	Energy from fat (%)	BMI (kg/m ²)	Fruit and vegetables (g/day)
Taste				
Ranked 1st/2nd	2,104	35	26.8	250
Ranked ≥ 3rd	1,974	34	27	280
Health				
Ranked 1st/2nd	2,024	34	26.6	311
Ranked ≥ 3rd	2,058	35	27.1	233
Nutrition				
Ranked 1st/2nd	2,017	34	26.4	312
Ranked ≥ 3rd	2,063	35	27.2	232
Cost				
Ranked 1st/2nd	2,052	35	28.1	202
Ranked ≥ 3rd	2,043	34	26.6	280
Convenience				
Ranked 1st/2nd	2,059	35	27.4	210
Ranked ≥ 3rd	2,040	34	26.7	279

Values in **bold** are significantly different at $P < 0.05$

Healthy food products should account for convenience and taste as the primary drivers of food choice and promote the sensory aspects of healthy food choice.

Relevance to consumer products

These findings have implications for the promotion of products to different consumer segments in order to achieve higher compliance with dietary guidelines and improved health outcomes. For example, targeting the younger male segment would benefit from focusing on taste and convenience as core product attributes when promoting healthy foods, with less emphasis placed on the health attributes.

However, a different approach is required for older female consumers, whose food choices are more frequently guided by health, nutrition and taste. Products targeted at this segment should seek to support their pre-existing health orientation.

Food industry and public health

This research highlights a potential opportunity for negotiation and collaboration between the food industry and public health bodies. Public health bodies and food companies can mutually benefit from incentives and supports to promote healthy products in a targeted and evidence-based manner.

Hence, the promotion of healthy eating guidelines and healthy food products should account for convenience and taste as the primary driver of food choice and promote the sensory aspects of healthy food choice rather than just the health attributes. Products and guidelines promoted in this manner may have a higher likelihood of having the desired impact, i.e., healthier food consumption patterns in all consumers.

Acknowledgements

This research was funded by the Department of Agriculture, Food and the Marine through the FIRM programme. ReVisData (13/F/527) and Sensory Food Network Ireland (13/SN/401).

Authors

Sinead McCarthy

Research Officer, Department of Agrifood Business and Spatial Analysis, Rural Economy and Development Programme, Teagasc Food Research Centre, Ashtown, Dublin 15
Correspondence: sinead.mccarthy@teagasc.ie

Mary McCarthy

Professor of Marketing, Cork University Business School, University College Cork



JANUARY 2018

January 10-13 RDS, Dublin

TEAGASC AT THE BT YOUNG SCIENTIST AND TECHNOLOGY EXHIBITION

Visit the Teagasc stand in the "World of Science and Technology", where attendees will be asked to give us their ideas for the future of farming and food. Teagasc sponsors a prize for the best agriculture and food presentation.

<http://btyoungscientist.com/>

Contact: catriona.boyle@teagasc.ie

January 30

Lough Rea Hotel, Co. Galway

February 1

Nuremore Hotel, Carrickmacross, Co. Monaghan

February 12

Knockranny House Hotel, Westport, Co. Mayo

NATIONAL HILL SHEEP CONFERENCE

The latest sheep research and advice will be presented at these regional events.

www.teagasc.ie

Contact: michael.diskin@teagasc.ie

January 31

Lyrrath Hotel and Conference Centre, Kilkenny

BUILDING A MORE RESILIENT TILLAGE INDUSTRY

The National Tillage Conference 2018 will be of great interest to all sectors of the tillage industry. The yearly event presents valuable information on a range of topics that can help growers and industry partners make crucial decisions for their businesses. Topics for discussion at the event include: oat agronomy; prospects for predicting spring barley protein and N requirements; Septoria resistance and control; the use of

Irish cereals in baking products; and, crop nutrition and soils. In addition, there will be rapid-fire presentations on six new research topics.

www.teagasc.ie

Contact: dermot.forristal@teagasc.ie

FEBRUARY

February 6-7

Budapest, Hungary

THE BIOECONOMY DRIVING SMART AND SUSTAINABLE CITIES

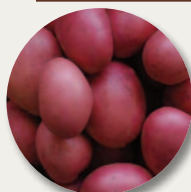
Attendees at Bioeconomy Impact 2018 (final project event) will hear from companies, community leaders and policy makers, all playing their part in driving sustainable innovation across Europe. The mission of CommBeBiz, in which Teagasc is a project partner, is to provide opportunities for European Bioeconomy researchers for skills training, networking and access to experts. This free to attend conference is open to bioeconomy researchers, agencies, start-ups, entrepreneurs and knowledge brokers.

www.commbebiz.eu

Contact: info@commbebiz.eu

February 20

Red Cow Moran Hotel, Dublin

NATIONAL POTATO CONFERENCE

This event brings together all sectors of the industry from growers to processors, with national and international speakers, as well as service industry professionals. There are a range of topics on the agenda from market information to nutrition, as well as technical papers on potato storage and pest control. There will also be an update on the recently completed joint initiative between Bord Bia, the IFA and Teagasc, which looked at growing salad potatoes.

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

February 27

Teagasc Ashtown Conference Centre

ENSURING THE CONTINUED SUCCESS OF THE BIOECONOMY IN IRELAND: PROGRESSING AND TRANSLATING RESEARCH

This half-day seminar will communicate findings from a recent Horizon 2020 European project, CommBeBiz, and discuss key ideas with all those interested in ensuring continued success of the Bioeconomy in Ireland. CommBeBiz is a Horizon 2020-funded co-ordination and support action finishing in February 2018. This project has been motivating and supporting researchers across the European Bioeconomy to deliver impact from their research projects.

www.scienceweek.ie

Contact: maeve.henchion@teagasc.ie

MARCH

March 13 Northern House Hotel, Edinburgh

JOINT TEAGASC/SRUC CONFERENCE – RURAL FUTURES: ADAPTATION TO CHALLENGES FACED BY RURAL COMMUNITIES

This is the first joint event with Teagasc and Scotland's Rural College (SRUC), with a number of high-level speakers from both countries. Keynote talks are by Ian Boyd, Chief Scientific Adviser at the Department of Environment, Food and Rural Affairs (Defra) and Liz Wedderburn, Assistant Research Director, AgResearch, New Zealand. The plenary sessions feature talks on: Adapting to Change: Policy, Agriculture and Rural Areas Post Brexit; Adapting to Change: Innovative Socio-Economic and Marketing Solutions; Adapting to Change: Innovative Technologies; and, Towards Common Solutions.

www.teagasc.ie

Contact: lance.obrien@teagasc.ie

APRIL

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 or david.kenny@teagasc.ie

MAY

May 8-9

Teagasc Ashtown Conference Centre

EUROPEAN SENSORY SCIENCE SOCIETY AGM AND CONFERENCE

Sensory Food Network Ireland hosts the European Sensory Science Society (E3S) Annual Symposium. The theme of the symposium is 'A Taste of Culture: Understanding the Global Consumer and Sensory Perception'. Speakers at the event include a number of high-profile international sensory science experts. There will also be a student competition, a showcase of Irish foods and excellent networking and collaboration opportunities.

www.e3sensory.eu/ and www.SensoryFoodNetworkIreland.ie

Contact Eimear Gallagher or Sinéad McCarthy:

SensoryFoodNetworkIreland@teagasc.ie

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

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