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Research

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Finding future farmers

SAFEGUARDING FOOD

DOES TERROIR EXIST FOR WHISKEY?

OUTLOOK 2020

teagasc
Agriculture and Food Development Authority

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Research integrity

Research integrity is a cornerstone of the confidence that partners, stakeholders and society have in researchers and research organisations. Teagasc, and the other research-performing organisations in Ireland, have published a statement on research integrity, committing to maintaining the highest standards. Research integrity is sometimes perceived as avoiding things like plagiarism, fabrication and falsification of data. These are certainly serious breaches of research integrity, but thankfully only occur very infrequently. Other areas that are of concern include issues around paper authorship, poor laboratory practices and research methods, poor experimental design, not preserving primary data or bad data management and storage, not disclosing conflicts of interest, misrepresenting publication records, and other failures to conduct research with the highest standards of integrity. While these may be less serious than fabrication and falsification of data, there are few researchers who have not come across instances that fall into one of these categories. We did not need the statement on research integrity to come along for research organisations and individual researchers to be vigilant to stamp out such practices, but I think there is now a greater awareness of the damage they can do to the reputation of an individual, an organisation or the whole research system. By and large, researchers are trusted by society for their expert views, and we must do all we can to avoid damaging that precious trust. Building awareness and training staff in best practice is very important, and the training now available in Teagasc and across all research organisations should be availed of by all concerned. We are currently in year two of a national training programme, and to date close to 200 research staff in Teagasc have completed this or will do so before the end of the year. Not alone is this the right thing to do, but also, the majority of Irish funders have made research integrity training a mandatory requirement for all award-holders and their research teams, and there are strong moves at EU level in this direction also. We must take individual and collective responsibility for having a research system where integrity is a fundamental principle.

Frank O'Mara
Director of Research
Teagasc

Macántacht taighde

Tá macántacht taighde ina cuid lárnach sa mhuinín atá ag comhpháirtithe, geallsealbhóirí agus ag an tsochaí i dtaighdeoirí agus in eagraíochtaí taighde. D'fhoilsigh Teagasc, agus eagraíochtaí eile a dhéanann taighde in Éirinn, ráiteas maidir le macántacht taighde, ag gealladh go gcoimeádfaidh siad na caighdeáin is airde. Breathnaítear corruair ar mhacántacht taighde mar rudaí amhail bradaíl, cumadh bréagach agus falsú sonraí. Is cinnte gur sáruithe iad sin ar mhacántacht taighde, ach ar an dea-uair, is annamh a tharlaíonn siad. Áirítear ar réimsí eile imní ceisteanna maidir le húdarú páipéir, droch-chleachtais saotharlainne agus drochmhodhanna taighde, drochdhearadh turgnamhach, gan sonraí príomhúla a choimeád nó drochbhainistíocht nó drochstóráil sonraí, gan coinbhleachtaí leasa a nochtadh, bréagléiriú a tabhairt ar thaifid foilseachán, agus teipeanna eile maidir le taighde a dhéanamh ar na caighdeáin is airde macántachta. Cé go bhféadfadh sé nach bhfuil siad sin chomh tromchúiseach le cumadh bréagach agus falsú sonraí, is beag líon na dtaighdeoirí nár tháinig ar chásanna a thagann faoi ceann de na catagóirí sin. Níor theastaigh uainn go dtiocfadh an ráiteas maidir le macántacht taighde chun cinn le go mbeadh heagraíochtaí taighde agus taighdeoirí aonair airdeallach chun deireadh a chur leis na cleachtais sin, ach sílim go bhfuil níos mó feasachta ann anois maidir leis an damáiste a bhféadfaí a dhéanamh leo ar cháil duine aonair, eagraíochta nó an chórais iomláin taighde. Tríd is tríd, tá muinín ag an tsochaí i dtaighdeoirí dá ndearcthaí saineolacha, agus ní mór dúinn gach rud is féidir linn a dhéanamh ionas nach ndéanfar damáiste den mhuinín luachmhar sin. Tá forbairt feasachta agus oiliúint a chur ar bhaill foirne ar an dea-chleachtas an-tábhachtach, agus ba cheart do gach duine lena mbaineann leas a bhaint as an oiliúint atá ar fáil anois in Teagasc agus ar fud na n-eagraíochtaí taighde ar fad. Táimid sa dara bliain anois de chlár náisiúnta oiliúna, agus go dtí seo chuir beagnach 200 ball foirne taighde in Teagasc an clár sin i gcrích nó déanfaidh siad amhlaidh roimh dheireadh na bliana. Ní hamháin gurb é seo an t-am cheart le hamhlaidh a dhéanamh ach, chomh maith leis sin, tá oiliúint ar mhacántacht déanta éigeantach anois ag maoinitheoirí Éireannacha do gach sealbhóir dámhachtana agus a bhfoirne taighde, agus tá céimeanna móra á ndéanamh ar leibhéal AE sa treo sin chomh maith. Ní mór dúinn freagracht aonair agus freagracht le chéile a ghlacadh as córas taighde a bheith ann lena bhfuil macántacht ina bunphrionsabal.

Frank O'Mara
Stiúrthóir Taighde
Teagasc

Walsh Fellowships seminar winners

The overall Teagasc Walsh Fellow of the Year 2019 is Hazel Rooney. Hazel was the winner of 'Best oral presentation and winner of Teagasc Gold Medal' at the annual Teagasc Walsh Fellowship seminar in Dublin recently. The title of her presentation was: 'Nutritional management strategies to optimise annual sow output, to promote the growth and development of progeny from large litters'. Hazel conducted her research in the Teagasc Pig Development Department, Moorepark, Fermoy, Co. Cork, and the School of Agriculture and Food Science, UCD.

Four finalists competed for the Teagasc Gold Medal, having won the competition in each of the four Teagasc research programmes. The finalists were: Hazel Rooney, Animal & Grassland Research and Innovation Programme; Emer Garvey, Food Programme; Damien Mooney, Crops, Environment and Land Use Programme; and, Mohana Priya Logakrishnan, Rural Economy and Development Programme.

The best food research presentation and winner of the Institute of Food Science and Technology Ireland (IFSTI) medal was Emer Garvey, who is located at the Teagasc Food Research Centre, Moorepark, Fermoy. The title of Emer's presentation was: 'Piece of cake? Unravelling the contribution of sugar and fat to the desirable flavour of baked confectionery products'.

Teagasc Director Gerry Boyle with Hazel Rooney, Walsh Fellow of the Year 2019.

Researcher profile

Orla O'Sullivan

Orla O'Sullivan is a Senior Research Officer (Computational Biologist) in the Food Bioscience Department, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork.

Orla joined Teagasc in 2006 following a postdoctoral fellowship at the Conway Institute in UCD. She worked as a Research Officer, Research Fellow and faculty member at Teagasc and the APC Microbiome Centre before taking up her current role in October 2019.

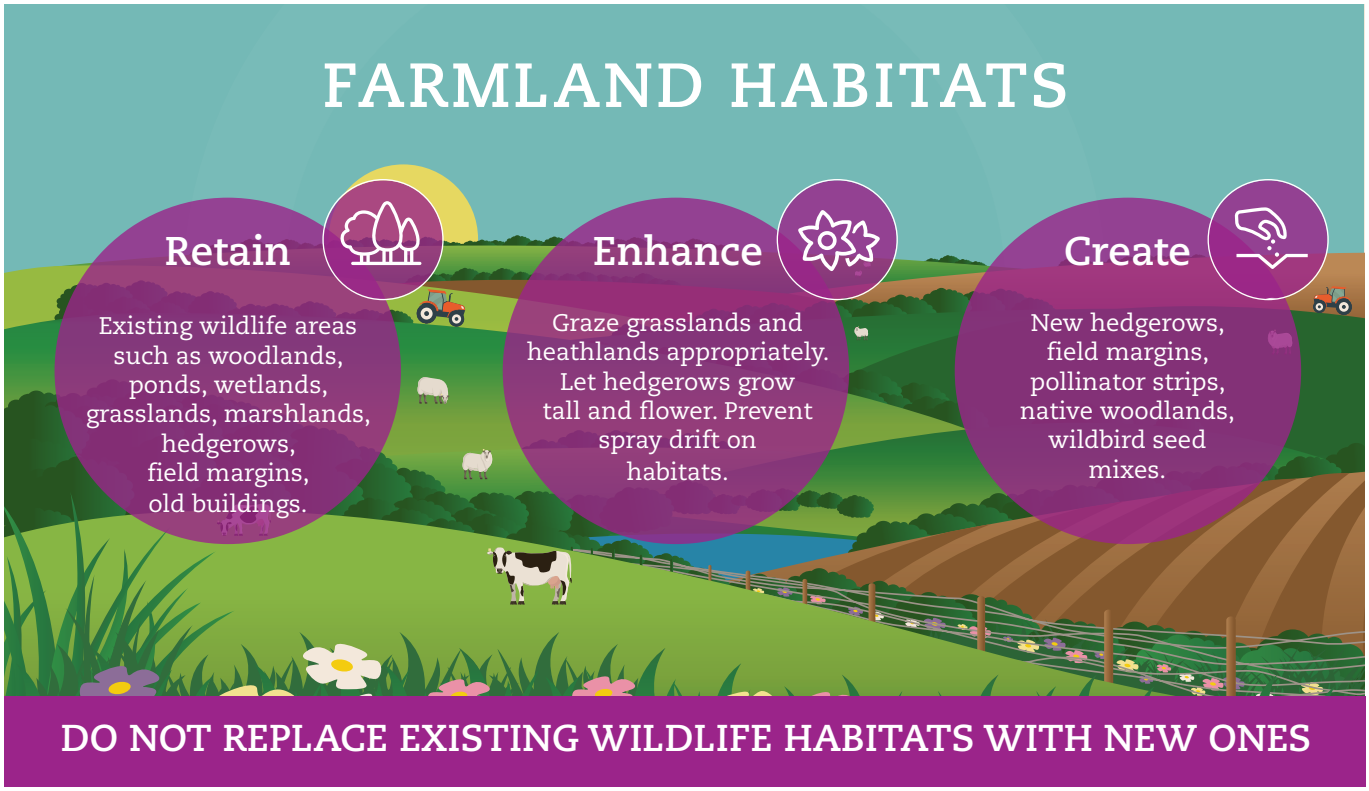
Orla's main research focus is investigating the role of physical fitness and diet in shaping the gut microbiome in both elite athletes and the general public.

Orla has a keen interest in science communication, and is a Teagasc Gateways initiatives presenter. She also prepares all publications with the Technology Transfer Office and APC IP Commercialisation case manager, and works on IP agreement organisation for bioinformatic analysis of genome and metagenome datasets for industry collaborators. She is a committee member of both the APC Microbiome Ireland and VistaMilk Education and Outreach Committees.

Orla has supervised a number of doctoral and postdoctoral students at Teagasc, and is also a supervisor on the MSc in Bioinformatics/Computational Biology at Cork institute of Technology and University College Cork. She has spoken at numerous international conferences, and her research has been published in a number of peer-reviewed journals, including: *The British Journal of Sports Medicine*; *Gut*; *Brain, Behavior, and Immunity*; and, *Nature*.

Orla was APC Scientist of the Year in 2014, and was the recipient of a Starting Investigator Research Grant from Science Foundation Ireland in the same year. She was listed as a Clarivate Highly Cited Researcher in 2018, and was awarded Science Foundation Ireland Early Career Researcher of the Year 2019.

Orla lives in Cork with her husband and two daughters. She is an avid sports fan and loves attending games, whether it be rugby, GAA or basketball.



SheepNet

Sheep farming is present in most EU countries. There are 830,000 farms and 85 million sheep in Europe, and 127,000 farms and 31 million sheep in Turkey. However, the EU sheep flock has declined by 15 % since 2000, reaching a critical threshold in some regions for the survival of the industry. While the decline in sheep and producer numbers is due to a number of factors, the main reason is low profitability due to low sheep productivity (number of lambs produced/ewes joined), which has not improved in many regions in the last 30 years. SheepNet, an EU-funded thematic network, was set up to improve sheep productivity (number of lambs reared per ewe joined) across the EU, thus improving the profitability and attractiveness of the sheep sector. SheepNet involved the six main EU sheep-producing countries (Ireland, France, United Kingdom, Romania, Spain, Italy) and Turkey. Many scientific and practical/innovative solutions already exist at local and national level but they are not widely transferred at EU level or they need to be adapted to specific livestock farming systems. The overall aim of SheepNet was to share knowledge between stakeholders to improve sheep productivity across Europe. SheepNet started in November 2016 and ended in October 2019. The final Irish seminar was held recently in Athenry, co-ordinated by Teagasc's Tim Keady and Alan Bohan. All results from SheepNet are available on www.sheepnet.network.

Highly cited 2019

Congratulations to the four Teagasc researchers who feature in the 2019 Web of Science Highly Cited list. This list recognises the world's most influential researchers of the past decade, demonstrated by the production of multiple highly cited papers that rank in the top 1 % by citations for field and year in Web of Science. A total of 29 Irish researchers featured on the list. Paul Cotter is Head of the Food Bioscience Department at Teagasc Moorepark Food Research Centre and APC Microbiome Ireland. Paul's research focuses on the microbiology and microbiomes of food (especially fermented and other dairy foods), food processing and production environments, and the gastrointestinal tract. Catherine Stanton is a Senior Principal Research Officer, Teagasc and APC Microbiome Ireland. Catherine's research includes nutritional aspects of dairy and functional foods, probiotic cultures, bioactive metabolite production, infant gut microbiota, and healthy proteins and fats that are produced by gut bacteria. Brijesh Tiwari, a Principal Research Officer in the Department of Food Chemistry at Teagasc Ashtown Food Research Centre, leads a research team aimed at developing new and improved processes for the agri-food sector. His research focuses on application of advanced food processing preservation technologies aimed towards key food industry challenges, and developing clean and green sustainable solutions to valorise food processing streams. Paul Allen, who recently retired from Teagasc Ashtown Food Research Centre, also made the list again this year. His interests covered a range of cutting-edge approaches to important meat research challenges.

Loss of a colleague – John Finnan obituary

Dr John Finnan.

It is with the deepest regret that we write about our colleague John Finnan, a Senior Research Officer in the Teagasc Crop Science Department, who died suddenly on October 6 in a light plane crash. A native of Athy, John was 52 and an accomplished pilot for over 20 years. He completed his PhD in Oak Park as a Walsh Fellow in March 1995, after which he worked as a postdoctoral researcher before taking up a position in the Environmental Protection Agency. John returned to Teagasc in April 2007 as a Research Officer, and throughout his career at Oak Park he led significant research initiatives in developing robust, practical management options for bioenergy crops such as miscanthus, hemp and willow, followed more recently by his ground-breaking work in oats management.

In total, John authored over 120 publications, with an incredible 47 independent research papers derived from his bio-energy work alone, developing an invaluable knowledge resource that covers all aspects of field management and crop agronomy for these crops.

On commencing the oats programme in 2012, John quickly established himself as an authority in oats agronomy among his national and international research peers, and was at the forefront of promoting to the industry the importance of the crop in tillage rotations.

From 2015 to 2018, John was Senior Editor of the *Irish Journal of Agricultural and Food Research*, Teagasc's open-access peer-reviewed publication. During this time John was instrumental in setting up an online production management system for the journal and maintained the highest standards in academic publishing at all times. An outstanding supervisor for his PhD students, John's attention to detail and understanding of scientific principles gave his team unparalleled insight into the importance of robust experimentation to deliver through-to-practice solutions for tillage farmers. While John's research impact has given us and the tillage sector a legacy that will have a positive impact for years to come, it was John's humility, sincerity, friendship and relaxed style of communication that endeared him to all who met him. John was a fantastic colleague and friend to so many and in the months ahead, while we mourn his loss, we are comforted by the fact that it was an honour and privilege to know and work with John as we remember a colleague who impacted so positively on people's lives.

Science Week

Science Week 2019 at Teagasc Ashtown.

Examining insects at Oak Park during Science Week 2019.

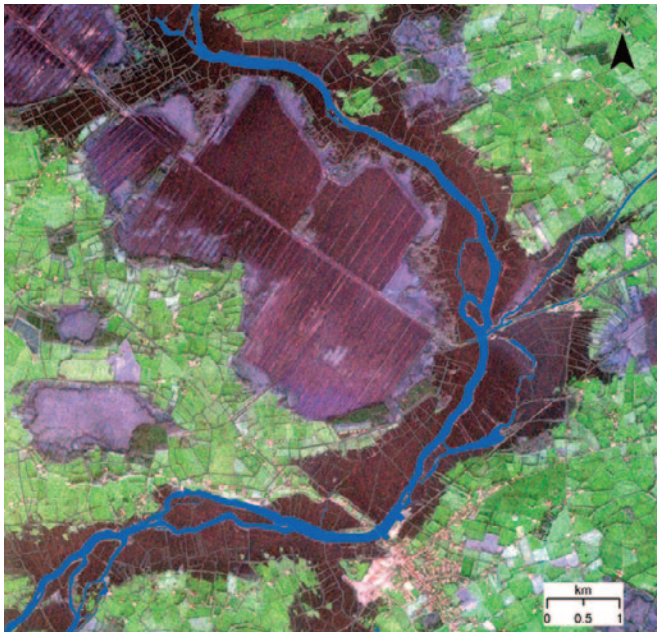
Well done to the hundreds of staff and Walsh Fellows from all over Teagasc who helped to make *Science Week 2019* a resounding success.

Teagasc hosted the *Festival of Farming and Food*, one of 13 regional festivals sponsored by Science Foundation Ireland. This included many exciting events around the country, all of which were free to attend. The theme of this year's Science Week was 'Climate Action'. The festival was a celebration of the science underpinning sustainable agriculture and food production in a series of events aimed at a broad audience, ranging from primary school students up to open events for the general public.

Teagasc research centres around the country also opened their doors for school visits (primary up to third level), where students got to perform hands-on experiments and find out about careers in STEM. There were also a number of events at local libraries and other venues, including the National Botanic Gardens and shopping centres, all adding to the week and sparking an interest in science for attendees.

Mapping Ireland's floods by satellite

A recent large-scale analysis of rural flooding published in Teagasc's *Irish Journal of Agricultural and Food Research* demonstrated the potential of free ESA Copernicus data to map the extent and impact of flooding in rural areas. Sentinel 1A RADAR images were used to produce detailed national flood extent maps every 12 days between November 2015 and April 2016. The maps monitored changes in flood extent in response to individual storms over the period and identified areas that had the most persistent flooding. Maximum flood area during this period was estimated to be 24,356 hectares, with persistent flooding (floods on eight or more consecutive occasions) identified on about 3,000 ha.
Lead author Rob O'Hara explains: "Rural areas provide an important ecosystem function to towns and cities by absorbing much of the impact of winter floods. Provision of this function however can have a negative impact on rural areas for a considerable period after the flood event. After the flood waters receded, the underlying soils remained saturated for several weeks. The impact to farmers was significant where winter fodder stores were exhausted and replacement grass could not be grazed.
Combining the Sentinel flood map with multispectral images from the NASA/US Geological Survey Landsat 8 satellite, the impact of persistent or late winter floods on spring grass growth was observed. Where soils were still saturated in April, the satellite images indicated significantly less growth and this did not recover to expected levels until July".



Flooding at Shannonbridge, Co. Offaly. The location of the River Shannon is indicated. Source: ESA Copernicus Sentinel 2A.

Prevention is better than cure

Antimicrobial resistance (AMR) is a serious threat to public health around the world with potential consequences for everyone. A major scientific conference to address this issue, ONE HEALTH – Awareness to Action, Antimicrobial and Anthelmintic Resistance Conference, took place in Tullamore recently. The event was organised jointly by Teagasc, the Department of Agriculture, Food and the Marine (DAFM), University College Dublin (UCD), Animal Health Ireland (AHI) and the Food Safety Authority of Ireland (FSAI).
The message from the One Health conference was clear: the more antibiotics we use, the more resistant bacteria that will emerge. Reducing antibiotic use in the animal health sector is critical to addressing AMR.
Michael Creed, TD, Minister for Agriculture, Food and the Marine, stressed that there will not be effective bacterial and parasitic disease treatment options in the future if we continue to use antibiotics and anthelmintics at the level at which they are being used currently. He stressed that "prevention is better than cure" when it comes to animal health. He said his Department's policy is to promote a strategy where there is a focus on being proactive rather than reactive when it comes to optimising animal health.
Teagasc Director, Gerry Boyle said: "We have a responsibility to play our part to preserve the effectiveness of antibiotics for future generations. The agri-food sector, both in Ireland and internationally, has a significant role to play to safeguard the use of antibiotics for society".

Pictured at the One Health conference were (from left): Lisa O Connor, FSAI; Gerry Boyle, Teagasc Director; David Graham, CEO, AHI; Caroline Garvan, DAFM; Michael Creed TD, Minister for Agriculture, Food and the Marine; Rob Doyle, DAFM; Michael Diskin, Teagasc; Nola Leonard, UCD; and, Kaye Burgess, Teagasc.

Our first step should be to reduce antibiotic usage in animal production systems. Achieving high standards of animal health will not only benefit primary producers from a productivity perspective, but will reduce our use of antibiotics to treat sick and ill animals, thus reducing the risk of developing AMR.
The overuse of antimicrobials, whether in human or veterinary medicine, is a key driver in the emergence of AMR. AMR could reverse the benefits achieved in animal healthcare and in human healthcare over the last 100 years. It's now time to move from awareness to action to meet these new challenges. The proceedings from the One Health conference are available on www.teagasc.ie.

Cork Discovers 2019

TEAGASC staff were out in force as part of Cork Discovers 2019.

Cork City was the location for 'Cork Discovers – A World of Research' on Friday, September 27. The Cork Discovers event was part of European Researchers' Night, which took place on the same night across 27 different countries this year.
European Researchers' Night is an annual event funded under the Marie Skłodowska-Curie pillar in Horizon 2020 with the aim of providing an exciting programme of free, interactive and entertaining public engagement events to show what science does for society and to inspire the next generation of researchers.
The Cork Discovers event was a collaboration between University College Cork, Teagasc, Cork City Council and UCC Academy. A huge thank you goes out to all the Teagasc staff who participated.

In the Discovery Hall, Bastiaan Molleman demonstrated micro-sensors for monitoring air quality and greenhouse gas emissions. María De La O Leyva Pérez showed how we can discover the DNA make-up for the perfect crisp.
Frauke Fedderwitz showed how insects influence food production and how we can help them. Elena Arranz and Simona Bavaro demonstrated the journey of proteins through the digestive system in an interactive 3D experience. Kata Trifkovik and Anita Pax demonstrated the food science of cheese. VistaMilk SFI Research Centre Deputy Director and Teagasc Researcher Laurence Shalloo spoke about sustainability and climate change at the speaker series 'Cork Talks', hosted by 96FM's Deirdre O'Shaughnessy. Orla O'Sullivan presented a workshop on training your gut microbiome. VistaMilk

Teagasc researcher María De La O Leyva Pérez in Devere Hall, UCC, explaining the perfect crisp.

From left: Teagasc staff Kim Reilly; Eimear Ferguson; and, Orla O'Sullivan at the VistaMilk SFI Research Centre stand at Cork Discovers.

Teagasc researchers Elena Arranz and Simona Bavaro were on hand to talk about proteins at Cork Discovers.

From left: Head of the Teagasc Animal & Grassland Research and Innovation Programme Pat Dillon; Lord Mayor of Cork Councillor John Sheehan; and, Vice President for Research and Innovation at UCC Anita Maguire visiting the Vision of Research and Innovation photo exhibition at Cork Discovers.

Teagasc researcher Bastiaan Molleman demonstrating sensor technologies from the SARMENTI Horizon 2020 project.

Teagasc entomologist Frauke Fedderwitz showing the public insect friends and foes.

Communications Manager Eimear Ferguson's workshop explored how sensor research will help to make better, more sustainable dairy products. Katie Hetherington and Tomás Byrne's interactive workshop showed how to be a plant detective, and Kim Reilly exhibited a selection of images from the Teagasc Vision of Research and Innovation photo competition.

The hashtag #CorkDiscovers trended on Twitter in Ireland on the night and the event attracted over 2,000 visitors to the UCC campus on Friday, with additional numbers in other venues across the city.

Acknowledgement

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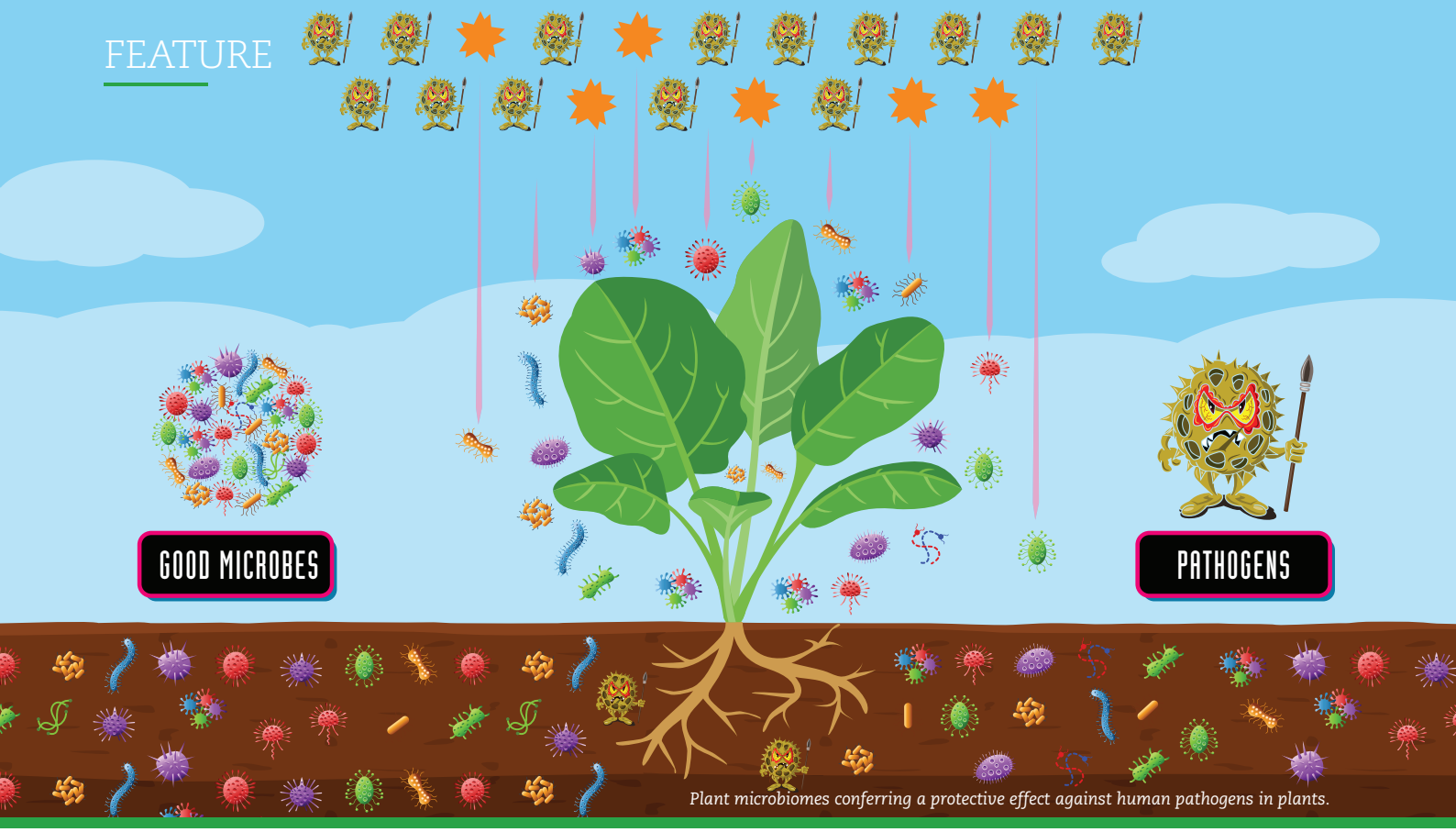

Plant microbiomes conferring a protective effect against human pathogens in plants.

Safeguarding food

TEAGASC researchers recently hosted an international stakeholder workshop, which focused on protecting fresh produce from human pathogens through an enhanced understanding of the plant microbiome.

Growing consumption of fresh produce and an increasingly complex international food supply chain necessitates that efforts to protect consumers of plant produce from human pathogens take a global dimension. Teagasc is working with researchers across 39 countries to deliver the best international scientific advice to growers on protecting their produce from microorganisms that can cause human illness.

Protecting fresh produce

With an enhanced emphasis on the impact the food we consume has on our health, there has been an increased consumer demand for fresh plant produce including salad, fruit and raw vegetable crops that can be supplied year round, and that can be consumed in a variety of different ways. Meeting this demand has resulted in the development of complex international produce distribution networks, and an increased need to ensure food safety standards. Ready-to-eat-crops, which by their nature are not cooked prior to consumption, require particular care during production to ensure that they are not contaminated with human pathogens. Food-borne outbreaks resulting from the consumption of fresh produce have been reported worldwide. It is clear that certain groups of human pathogenic microorganisms are well adapted for surviving and living on plant crops when a contamination event takes place, and in some cases, microorganisms similar to pathogens can be considered part of the normal microbial community (or microbiome) associated with the crops. Key to safeguarding consumers is: minimising the potential for contamination of crops with human pathogens; understanding the capacity of human pathogens to integrate into the plant microbiome; and, determining if any elements of the microbiome pose a risk to human health. As food crosses borders, a co-operative approach is required to ensure safe production practice.

Role of microbiomes in plant protection from pathogens

Plants naturally have a diverse community of microorganisms associated with them that includes bacteria, fungi, viruses, archaea and protozoa. The plant microbiome is critically important for crop health. It facilitates the establishment of the plant, provides essential nutrients and vitamins, enhances tolerance to stress experienced by the plant, and can provide protection from colonisation of the plant by plant or human pathogens. The latter is achieved by the microbiome stimulating plant defences, competing with the pathogen for resources, infecting or predating on the pathogen, or otherwise being directly antagonistic to pathogen establishment. The microbiome that forms around the plant system is impacted by a wide range of factors, including climate, soil type, and the type of crop that is grown. Further, how we manage these crop systems has a strong impact on the plant microbiomes and the soils they grow in. Agricultural practices such as fertilisation, tilling, manure amendments, irrigation, liming, etc., can all change the composition of the microbial community and how it is functioning. From both a plant health and consumer safety perspective, understanding how the microbiomes associated with crops are altered by agricultural practices (either positively or negatively), and what impact this has on their capacity to

Some participants in the best practice stakeholder workshop pictured in Teagasc, Dublin (September 2019).

Pictured (left) are participants from the recent workshop on a tour of horticultural facilities at Teagasc Dublin, led by Michael Gaffney, Teagasc.

suppress pathogens that might cause illness in consumers, is important for informing best agricultural practice.

Huplant Cost Action

The Huplant Cost Action was established in 2017 and will run until 2021 with the main objective of combining and strengthening pan-European research efforts on the role that plant microbiomes play in the ecological behaviour and public risk of human pathogenic microorganisms. Huplant seeks to understand the ecology of these organisms in plants, identify them, assess whether they cause a risk to human health, and determine sanitary and agricultural management procedures to control the risks from microorganisms during production. Supported by Huplant, a recent 'International Stakeholder Workshop on Best Practice for the Control of Human Pathogenic Microorganisms in Plant Production Systems' was held by Teagasc in Dublin, with the aim of bringing together relevant stakeholders to examine hazards and control strategies in plant production systems in order to ensure the biological safety of horticultural products. With a particular focus on examining interventions used across Europe, the regulatory landscape and undertaking risk analysis, the workshop aimed to generate a series of best practice recommendations that could feasibly be implemented by growers, and identify barriers to implementation of current best practice.

Acknowledgements

Huplant control (Control of human pathogenic micro-organisms in plant production systems) is a COST (European Cooperation in Science and Technology) action (CA 16110) scientific network supported by the EU Framework Programme Horizon Europe.

For more information go to https://huplantcontrol.igzev.de

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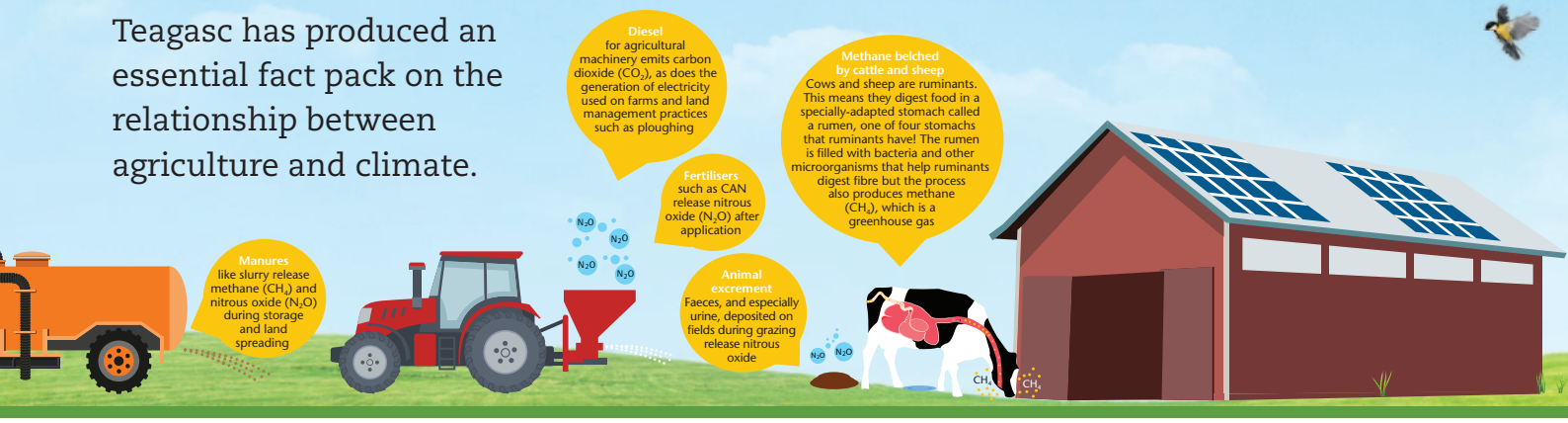
Agriculture and climate change

Teagasc has produced an essential fact pack on the relationship between agriculture and climate.



What's climate change and how will it affect Ireland?

Greenhouse gases (GHGs) are a collection of gases that act as a blanket around the earth. That's because heat from the sun reflects off the earth and is trapped by layers of gas in the atmosphere. Without this, the earth would be frozen, but increased amounts of GHGs in the atmosphere in recent decades are causing global temperatures to rise, which causes climate change.

For Ireland this could mean:

Wetter winters	More intense storms and rainfall; increased likelihood and magnitude of river and coastal flooding.
Drier summers	Water shortages in summer, heat stress in animals.
More frequent extreme weather events	Such as storms and droughts.
Increased risk of new pests and diseases of plants and animals	This may make it impractical to grow certain crops and increase some diseases and parasites.

Emissions from agriculture in Ireland

The sources of GHG emissions are different in Ireland from other European countries. In most countries in Europe, the human population is greater than the cattle population, so emissions are much greater from human or industrial sources than from agriculture.

Why do we need to reduce GHG emissions?

The term carbon footprint is used to describe how much carbon goes into the air because of something done by people. Driving a car or taking a flight has a carbon footprint, as does the production of milk or meat or the growing of crops.

Ireland's carbon footprint for food is good

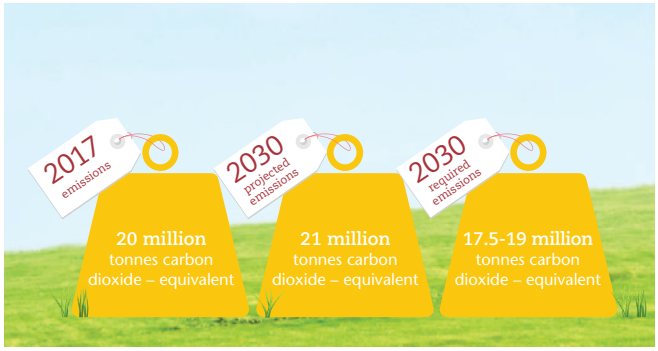
Farmers have made great progress in reducing the footprint in recent years by improving their efficiency through better animal breeding, grassland management and utilisation of animal manures. However, total emissions from agriculture are increasing.

The reason is simple: we have a bigger cattle herd since the ending of milk quotas. GHG reduction targets aim at reducing total emissions – rather than just reducing the carbon footprint. Reducing the carbon footprint of activities is important, but if the amount of an activity increases at the same time (e.g., the number of cows), then it becomes harder to reduce total emissions.

Currently, agriculture in Ireland:

- accounts for 33 % of our total greenhouse gas emissions;
- but has the lowest carbon footprint of milk in the EU (joint lowest with Austria);
- and the fifth lowest carbon footprint of beef in the EU; and,
- these are low because we mainly use grass to produce milk and meat.

The Irish Government's Climate Action Plan targets for agriculture are:



International obligations

Ireland has signed up to comply with international climate agreements such as the Kyoto Protocol, the Paris Agreement and the EU Effort Sharing Agreement. These agreements require total emissions to be reduced, not just a decrease in carbon footprints.

Opportunities

Making agriculture more environmentally sustainable is good for the clean, green image of Irish agriculture, which is an important factor that consumers consider when they choose to buy food from

Ireland. Globally, consumers want food that has a low environmental impact and this could create new markets. Ireland is already highly regarded by consumers for the environment in which we produce food.

How can farmers reduce GHG emissions?

By optimising nitrogen fertiliser use

- Switching to protected urea fertiliser – this is specially treated to help reduce the loss of nitrogen into the atmosphere (by up to 70 %).
- Ensuring optimal soil fertility improves the uptake of fertilisers (use a soil test).
- Planting clover – this plant absorbs nitrogen from the air and returns it to the soil, reducing the need for chemical fertiliser application. A well-developed white clover pasture reduces nitrogen fertiliser needs and, therefore, reduces carbon footprint significantly.

By better use of slurry

- Low-emission slurry spreading (LESS) technologies, such as trailing shoe slurry spreaders, dribble bars or injector systems can reduce GHG emissions.
- Spreading slurry early – application of slurry in the spring time reduces GHG emissions due to more appropriate weather conditions and less storage time of slurry.

How can farmers reduce GHG emissions?

By producing renewable energy and saving on energy use

- Upgrading to new technologies could reduce electricity use on farms by up to 60 % (and related carbon dioxide emissions). Technologies include plate coolers (for cooling milk), heat recovery systems, vacuum pumps and solar panels.
- Anaerobic digestion can create biogas/biomethane from grass, food waste, slurry and other farm wastes.

By using better farm management practices

- Improving animal genetics, lengthening the grazing season and using white clover in pastures.

By planting forestry, woodlands and hedgerows

Forests, trees and hedges help reduce climate change effects by absorbing carbon dioxide from the atmosphere. Ireland has one of the lowest levels of forest cover (11 %) in Europe and there is a lot of potential to improve this.

- Increasing the level of commercial forestry, which produces timber.
- Planting trees on farms improves farm drainage, provides shade for farm animals, and protects habitats and watercourses.
- Amenity forestry provides places for walking and other activities.
- Hedges store a lot of carbon and enhance biodiversity.

Future role of science

Science has provided some solutions to reducing GHG emissions and is working on additional solutions for the future. We need more research on each of the folowing areas.

Carbon sequestration

Carbon sequestration means the removal of carbon dioxide from the atmosphere and it has a large potential to help us offset GHG emissions in Ireland. This potential can be mostly achieved by planting trees but also by management of grasslands, water table height for peat soils, and tillage. We need more research on these.

Animal feed supplements

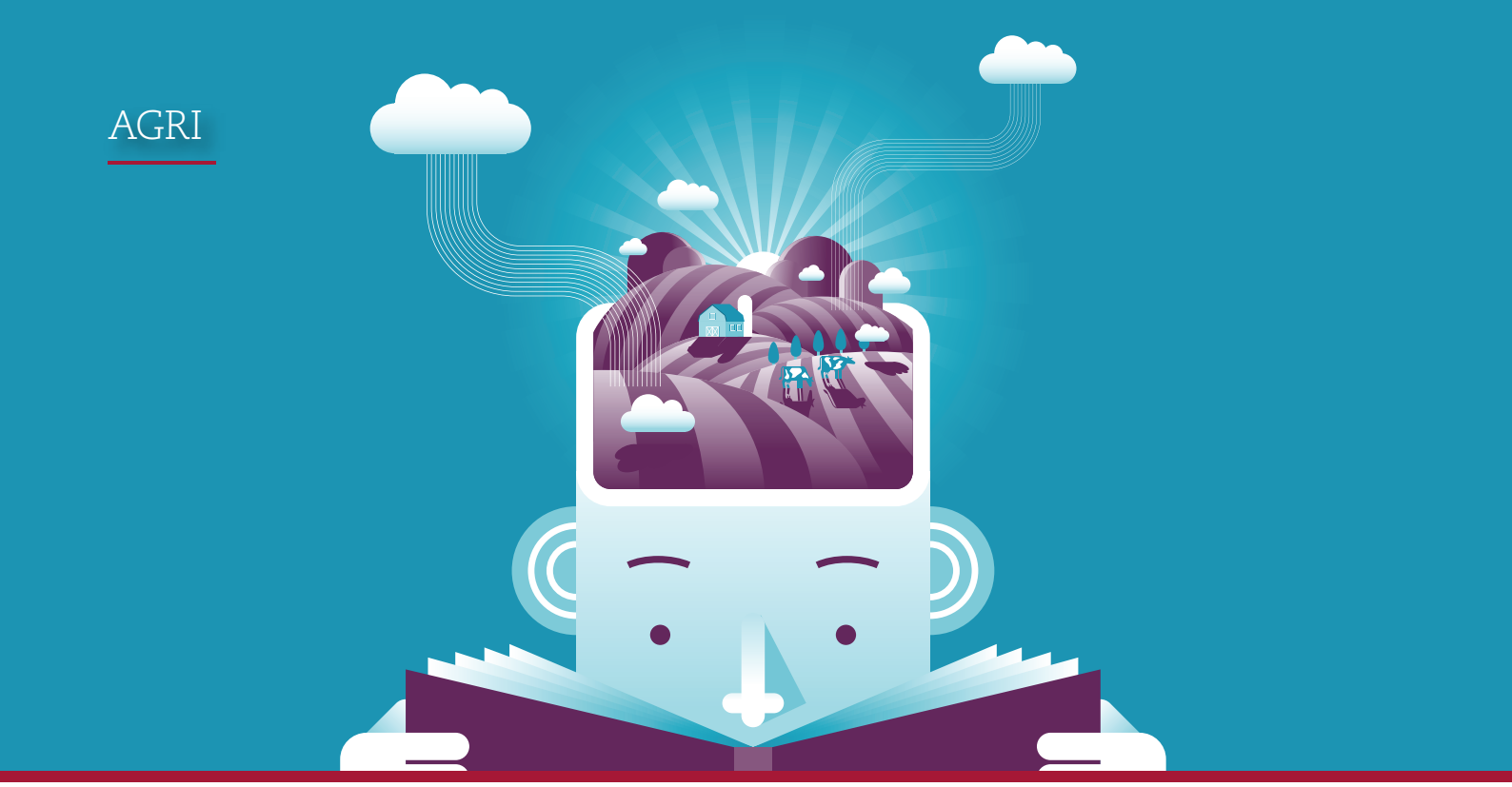
Adding substances to animal feed or the development of methane inhibitors both have the potential to reduce methane production in cattle.

Managing soil

Better nutrient utilisation could reduce GHG emissions by reducing input of synthetic fertilisers.

Slurry additives

Treating manures and slurries using compounds has been shown to reduce losses of phosphorus, reduce ammonia emissions from land spreading, and reduce methane and ammonia emissions during storage.



Finding future farmers

TEAGASC research is looking at secondary school students' perceptions of and attitudes towards a career in dairy farming.

The availability of a constant supply of highly skilled young entrants is among the main challenges common to dairy industries worldwide. In Ireland, the requirement for energetic and skilled entrants is amplified by the growth in the dairy sector in recent years. Although Irish grazing systems are considered simple in design when compared with more intensive and confined systems, the seasonal workload and specific challenges of a grazing system require uniquely skilled individuals. Recent reports indicate that there is a major skills shortage within the sector, and the dominant perception remains that it is necessary to be from a farming background and to be designated as a successor to consider a career in dairy farming (Deming *et al.*, 2019). Changing such perceptions is imperative to attract new entrants from farming and non-farming backgrounds alike, and this has led to increased interest in understanding the factors that influence the occupation choice of school leavers.

To ascertain the perceptions and attitudes of adolescents towards careers in dairy farming, a survey with 35 closed-ended questions was devised. The target population was students who were registered to attend one of three agri-information events held in March 2017, November 2017 and March 2018 at Teagasc, Moorepark, Co. Cork. The students surveyed were from urban and rural schools in Munster, where dairy farming is more prevalent than in the rest of Ireland. All students were surveyed before the events started, and hence were not influenced by the events.

Description of students surveyed

Of the students surveyed (240 females and 246 males), the average age was 17 years and students were in fifth year. The majority of students (342; 84 %) were studying agricultural science for their Leaving Certificate. A total of 61 % of the students surveyed were from a farming background, with dairy farming the most common farming enterprise (49 %). Of the students living on a farm, 56 % reported having had a discussion on the future ownership of the farm with their parents.

> Increasing public understanding of the complex relationship between agriculture and climate change will ultimately lead to more informed decisions and policies around agricultural sustainability and the environment in the future.

Results

Over half of the students surveyed (53 %) had decided on their preferred career choice and only 31 % had considered a career in dairy farming. The people who had the greatest influence on student career choices are presented in **Figure 1**. Student perceptions of dairy farming are presented in **Table 1**. Additionally, 52 % of the students thought the work/life balance was inferior compared with other careers, while 12 % thought it was better than other professions. The workload of dairy farmers was thought to be hard or very hard by 82 % of the students. Some 47 % of respondents thought the salary in dairy farming was similar to what was achievable in other careers.

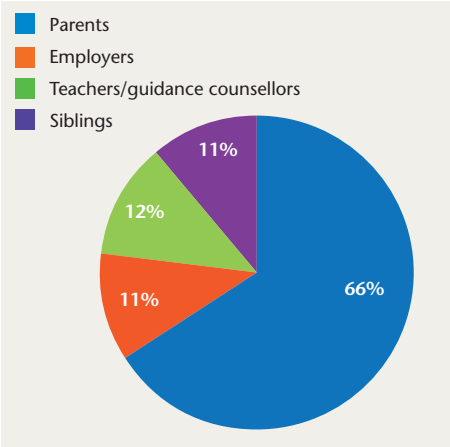
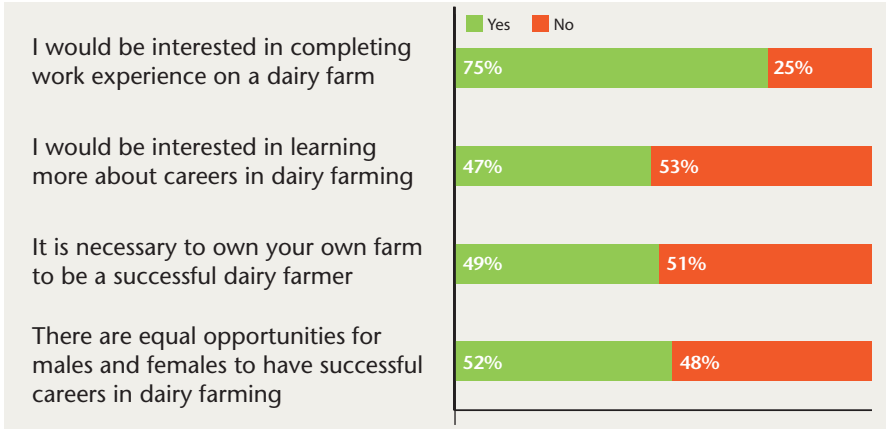


FIGURE 1: Main influencers of students' career choice.

Table 1: Students' perceptions of dairy farming.



Impact of studying agricultural science on career perception

Of the 342 respondents studying agricultural science, 188 (56 %) had decided on their careers, with 37.6 % considering a career in dairy farming. More male students (38.3 %) were interested in a career in dairy farming compared to female students (18.5 %). When asked if they were interested in learning more about careers in dairy farming, 56 % of male students and 52 % of female students said yes. The majority (83 %) were interested in completing work experience on a dairy farm (86 % for male, 79 % for female).

Implications

There is an opportunity for the Government to give increased attention to agriculture in school curricula. This could be timely in the context of greater public interest in food, agriculture and climate change, and could generate greater interest among adolescents in primary food production, especially if combined with a work experience element. This could provide adolescents and their parents with a better understanding of opportunities in primary agriculture. Increasing public understanding of the complex relationship between agriculture and climate change will ultimately lead to more informed decisions and policies around agricultural sustainability and the environment in the future.

Conclusion

New entrants to dairy farming are critical for generational renewal and to facilitate innovation and growth within the sector. Hence, understanding student perceptions of dairy farming careers, and the factors that influence prospective recruits, is essential. The values traditionally associated with farming (love of the land and hard work) are no longer sufficiently attractive to 21st century adolescents. Coupled with inadequate knowledge and understanding of dairy farming, students are dissuaded from considering it as a career option. Work–life balance, career development opportunities and flexibility are all important to adolescents. For the dairy industry to attract a sufficient number of high-quality recruits, significant additional efforts must be made to address negative perceptions by better educating both students and parents about the benefits of dairy farming careers. One option to increase students' knowledge of dairy farming is for a short work placement to be incorporated into the school curriculum.

Acknowledgements

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References

Deming, J., Macken-Walsh, Á., O'Brien, B. and Kinsella, J. (2019). 'Entering the occupational category of 'Farmer': new pathways through professional agricultural education in Ireland'. *The Journal of Agricultural Education and Extension*, 25 (3): 63-78.

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New insights into the feeding value of grazed pasture

A TEAGASC collaborative project with Cornell University is examining the true nutritive value of grazed pasture, and its role in dairy cow diets.

Introduction

The population of the world is projected to surpass 9.6 billion by 2050. This may reduce availability of human-edible cereal and protein products (e.g., maize and soybean) as feeds for livestock production. To maintain a significant contribution to net food production, ruminant production systems may need to increase reliance on the unique ability of ruminants to convert the most abundant human-inedible organic compound on earth, cellulose, into human-edible food. A primarily pasture-based diet provides an efficient and robust system to optimise this ability, as it involves the consumption of home-grown human-inedible forage, which minimises environmental impact, and supports a resilient business model for the farmer. There are, however, opportunities to increase the efficiency and productivity of pasture-based systems by incorporating more nutrients (i.e., nitrogen and carbon) into milk and meat products. Here we describe a collaborative project with Cornell University that is actively exploring new nutritional management tools for pasture-based dairy production systems to increase the capture of nutrients into milk.

Nutritional modelling

Nutritional modelling provides greater understanding of the balance between nutrient supply from the diet and the animal's requirements. The Cornell Net Carbohydrate and Protein System (CNCPS) is a tool that is used widely for diet formulation in the US, with growing usage across the world. Requirements for energy, protein, vitamins and minerals are quantified based on inputs from the user describing the cow, her environment and her current level of milk production. The supply of each of these nutrients is also quantified based on the animal's intake and the characteristics of the diet the cow is consuming. In pasture-based systems, there are a number of dietary strategies available to enhance the capture of nutrients, such as improved pasture management techniques, optimising concentrate supplementation, breeding more suitable plants, and the development of mono- or multi-species swards. To select the optimal strategy, however, quantitative knowledge of how the diet interacts with the host and the nutrients it supplies is critical. The CNCPS can help to provide this increased understanding through the combination of mathematical modelling allied with in-depth feed chemistry analysis.

There are opportunities to increase the efficiency and productivity of pasture-based systems.

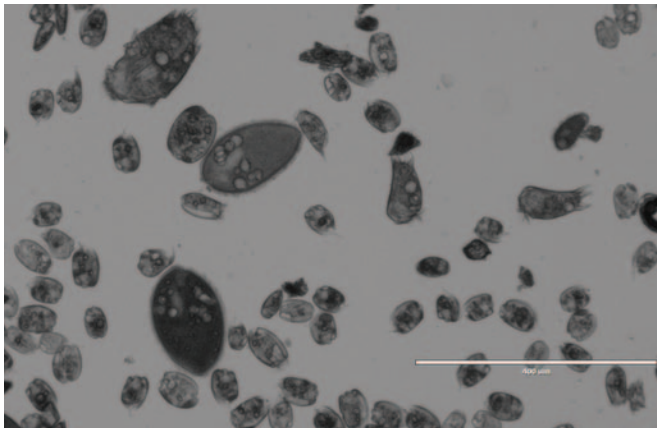

FIGURE 1: Mixed protozoa, a subset of rumen microbes that contribute to the nutrient supply of ruminants.

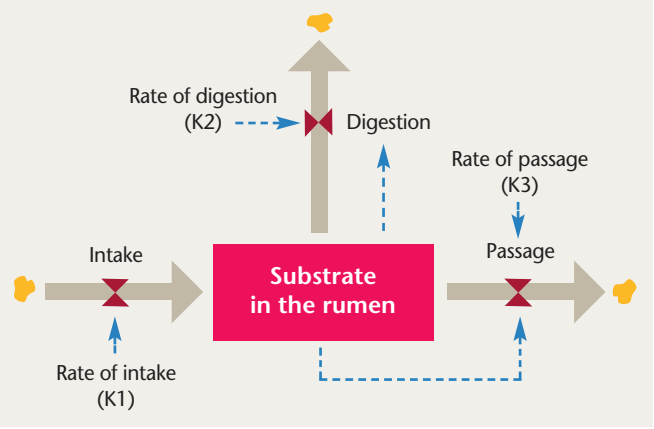

FIGURE 2: Diagram of the mathematical modelling approach utilised by the CNCPS to represent the dynamics of digestion in the rumen.

To optimise microbial output and the capture of nutrients within the rumen, it is essential that the grazing animal consumes large quantities of highly digestible material.

Feed chemistry

A major strength of the CNCPS is the feed chemistry it utilises to characterise each feed and hence the animal's diet. For example, the measurement of crude protein is differentiated into five fractions that differ in the rate at which they degrade in the rumen, their digestibility in the small intestine, and their potential amino acid (AA) contribution to the animal. This suite of chemistry analysis was carried out on Irish perennial ryegrass (PRG) swards, and the results were entered into the CNCPS. The model predicted that a large proportion of the PRG AA would be digested in the rumen, and hence contribute poorly to absorbable AA supply.

To evaluate this prediction, a digesta flow experiment was conducted in Teagasc Moorepark. In the experiment, we observed that 88 % of the PRG AA was degraded by the microbial population in the rumen, with only 12 % escaping to the small intestine. Therefore, a large proportion of the actual AA absorbed by the grazing cow was in the form of microbial AA washing out of the rumen (**Figure 1**) rather than coming directly from the feed eaten by the cow.

To optimise microbial output and the capture of nutrients within the rumen, it is essential that the grazing animal consumes large quantities of highly digestible material. The capability to achieve this is strongly influenced by the quantity and quality of the plant cell wall in the diet, measured as neutral detergent fibre (NDF). Animal experiments support the theory that faster rumen degradation of the NDF fraction of the feed will reduce physical fill over time, and allow greater voluntary feed intake to be achieved. A laboratory procedure to describe this degradability has recently been developed at Cornell University. The CNCPS combines outputs from this laboratory analysis with other pre-defined experimental relationships in a computer program (**Figure 2**) to predict animal outcomes. Results from the digesta flow experiment indicate that the CNCPS can predict this behaviour in pasture-fed dairy cows with high precision (< 2 % error). The ability to carry out these new feed chemistry analysis techniques is currently being developed at Teagasc Moorepark.

Implications

The new tools described can provide greater understanding of the nutrition of grazing dairy cows. Through precise quantification of the nutritional interactions involved, strategic supplementation or diet optimisation can be implemented to increase the efficiency and productivity of pasture-based systems. These new tools can also provide far-reaching insights; for example, to describe future plant breeding objectives or the screening of pasture species in multi-species swards. Improved swards, optimised for traits such as reduced ruminal digestion of plant AA, could increase net human food production, lower environmental impacts, and increase the financial resilience of pasture-based systems.

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Measuring integrated pest management

A survey of farmers carried out by TEAGASC and collaborators is helping to measure the use of integrated pest management on temperate arable farms.

In arable crops, pests comprising diseases, weeds and insect pests annually threaten yields and, in turn, the profitability of these farming systems. To prevent such outcomes, farmers have become increasingly reliant upon pesticides. Unfortunately, the availability of pesticides, whether through the development of resistance and/or increased restrictions on usage resulting from changes in regulations, is becoming increasingly constrained. In response to this, the integration of different approaches to pest control in what is known as integrated pest management (IPM) is regarded as key to achieving pest management in a manner that is environmentally, economically and socially sustainable. IPM practices are built upon eight guiding principles (Barzman *et al.*, 2015) (**Table 1**), including an emphasis on prevention or suppression of the initial development of a pest in order to minimise the need for later chemical intervention. Unfortunately, given the broad nature of these principles, and the difficulties often experienced in providing clear and concise advice on how each measure should be implemented on farm, the applicability of IPM in certain cropping systems is questioned.

In arable farming the eight principles are often implemented in some form or other, and while often regarded as good agricultural practice, there is a need as part of the Sustainable Use Directive (SUD) to ensure that these are recognised within the IPM principles. Although most on-farm practices adhere to the principles, determining exactly where they fit and quantifying their exact value to the IPM goal is often ambiguous and can be dependent on the evaluator (farmer, regulatory, advisor or researcher). If IPM practices are to be promoted on farm, it is essential to determine current uptake levels and, objectively, what motivates farmers to adopt IPM. To address these questions, a survey was carried out within the EPIC project funded by the Department of Agriculture, Food and the Marine, in collaboration with the Scottish Rural College (SRUC), the University of Reading, and the AgriFood and BioSciences Institute (AFBI) in Northern Ireland. Farmers responded to a questionnaire comprising 22 questions, designed to collect information on: the farm and farming structure; specific crop protection practices implemented on farm for control of diseases, weeds and insect pests; and, the farmers' perception of IPM (Creissen *et al.*, 2019). To limit any potential bias due to prior attitudes to IPM, the survey title, 'Best Arable Practice Survey', did not mention IPM.

Survey

Eight questions relating to IPM were asked, ranging from questions about farmers' decisions to choose a particular plant variety, to specific practices they employ to control diseases, weeds or insect pests. While some of these questions could be assigned to individual IPM principles, others spanned multiple principles. This in itself highlighted the difficulties often experienced by growers in classifying specifically what they do under the banner of IPM. To overcome this, and to place a value on each practice in terms of IPM, a stakeholder workshop was established. At this workshop, representatives of various stakeholder groups involved in arable farming were asked to rank the various potential responses to each question on the basis of their relevance to IPM. Subsequently, each stakeholder was asked to rank the different questions in terms of importance. In doing so, the workshop established a metric from which individual survey responses could be scored in terms of level of IPM uptake. To further ensure the validity of this metric, an additional round of stakeholder engagement took place across each of the four countries, with the option to change ranking for scores both within and between the questions. The responses from this second stakeholder engagement were subsequently used to score the survey responses on a scale of 0-100, with a score of 100 being the theoretical maximum level of IPM implementation.

Results

By engaging with and comparing the responses of the stakeholders from the various sectors involved in arable farming, and from the

Table 1: The eight guiding principles of IPM as outlined by Barzman *et al.* (2015).

Principle	Description	Components
1.	Prevention and suppression	Crop rotation, cultivation techniques, varietal resistance, phytosanitary measures, beneficial organisms
2.	Monitoring	Field monitoring, forecasting, seeking expert advice
3.	Informed decision-making	Protection measures based on expert advice, action thresholds
4.	Non-chemical methods	Preference for biological and physical control methods over chemical
5.	Pesticide selection	Using pesticides that minimise negative effects on human health and the environment
6.	Reduced pesticide use	Reduced doses, reduced application frequency considering the risk for development of pesticide resistance
7.	Anti-resistance management	Alternation/mixing pesticides containing multiple modes of action
8.	Evaluation	Assessment of the efficacy of control treatments used to inform future management decisions

different countries, it was possible to determine if a consensus on what constitutes IPM could be found. While some variation in stakeholder responses was evident, most notably for the IPM components/survey questions "What influences your choice of cereal variety?" and "Membership of an agronomy/crop discussion group", these contributed least to the overall IPM metric. Also, although no significant differences were observed between the countries or stakeholder origin in terms of what they felt IPM was (i.e., what components contributed to it), there was a tendency for stakeholders from Scotland to place less importance on reasons for adopting an arable rotation ("Why do you typically use an arable rotation?"). When this agreed metric was applied to the survey respondents, much as expected, a wide range of IPM uptake levels was observed.

Promisingly, all farmers practised some level of IPM (lowest score attained was 27.2 points out of 100), with a mean across all respondents of 65.1. However, although attainable, no farmer achieved the theoretically maximum level possible, with only 13 of the 225 respondents scoring > 85 points. With the ability to quantify levels of IPM practised on arable farms now established, the next steps are to address what drives different levels of IPM adoption. By further exploring the data, including perception of IPM and the role of farm/farmer structure, it is hoped to provide the information to inform the policy and practice changes through which further increases in IPM on arable farms can be achieved.

References

Barzman, M., Barberi, P., Birch, A.N.E., Boonekamp, P. and Dachbrodt-Saaydeh, S. (2015). 'Eight principles of integrated pest management.' *Agronomy of Sustainable Development*, 35: 1,199-1,215.

Creissen, H.E., Jones, P.J., Tranter, R.B., Girling, R.D., Jess, S., Burnett, F.J., *et al.* (2019). 'Measuring the unmeasurable? A method to quantify adoption of integrated pest management practices in temperate arable farming.' *Pest Management Science*. Available from: doi.org/10.1002/ps.5428.

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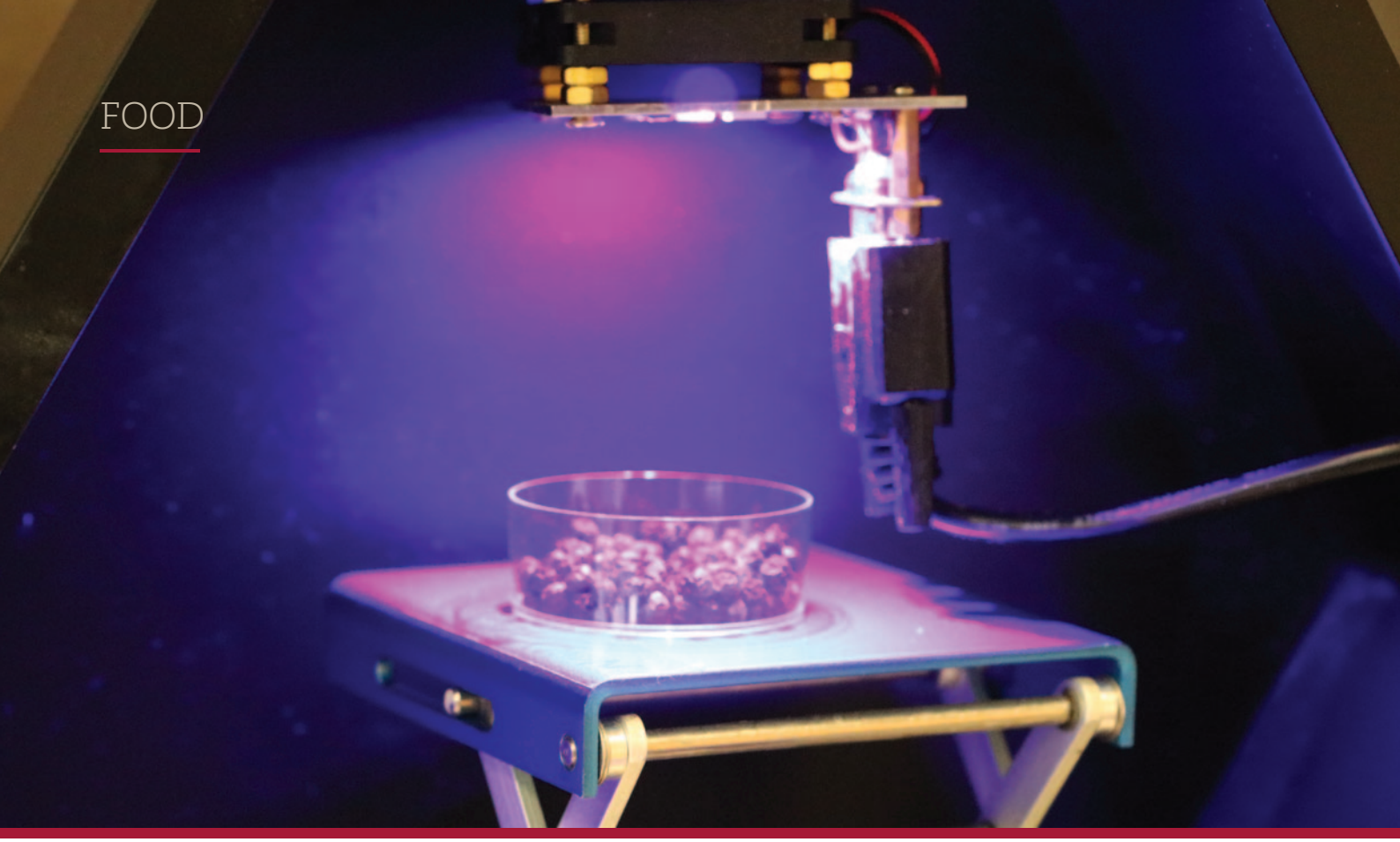

Food decontamination – seeing the light

TEAGASC researchers are investigating the potential of ultraviolet light-emitting diodes in food decontamination.

Ultraviolet light-emitting diodes (UV-LEDs) emit monochromatic light, which enables customised UV-LED disinfection systems at specific wavelengths to be developed. The application of UV-LEDs for disinfection purposes has been studied in recent years and now researchers are focusing on the application of this technology in the food industry. Recent studies have shown promising results that highlight the potential of this technology as a novel food decontamination tool.

LEDs are an alternative source of UV light, suitable for food industry applications that are safer, more environmentally friendly, and are becoming increasingly economical.

UV light technology has been investigated extensively, and has been used at commercial level across many fields, from medical device sterilisation to water treatment. UV is electromagnetic radiation within the 10 to 400 nm range on the electromagnetic spectrum, between X-ray and visible wavelengths. UV light may be subdivided and characterised based on wavelength and application. Three wavelength subdivisions are widely used in the scientific literature, namely UVA (315-400 nm), UVB (280-315 nm) and UVC (<280 nm). It should be noted that these classifications vary throughout the literature. UVC, which is known as the germicidal wavelength as it is highly effective, can damage the DNA of microorganisms because maximum DNA absorption occurs in the same range. UVA radiation mainly inactivates microorganisms by causing oxidative disturbance to the other biomolecules within the microorganism (Hinds, O'Donnell *et al.*, 2019).

Potential in the food industry

UV radiation has great potential in the food industry as a decontamination tool due to its many benefits and applications. However, traditional sources of UV, such as mercury lamps, are unsustainable and inefficient. LEDs are an alternative source of UV

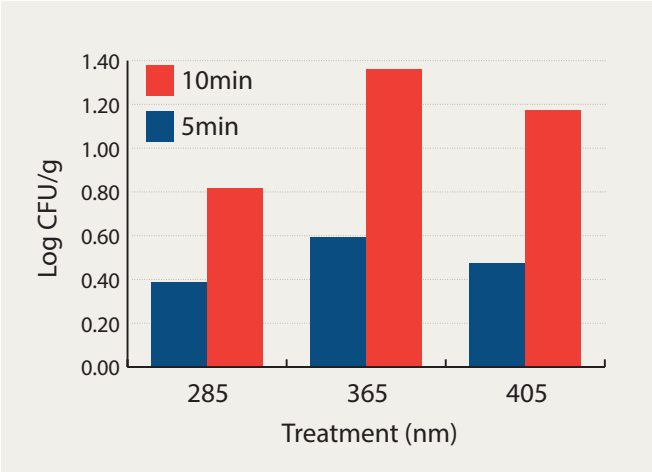

FIGURE 1: The effect of various UV treatments (285, 365, 405 nm) on the bacterial load in black pepper.

light, suitable for food industry applications that are safer, more environmentally friendly, and are becoming increasingly economical due to advancements in the semiconductor industry. As this is a novel approach, there are a limited number of studies that have investigated the potential of UV-LED systems for inactivation of food pathogens on solid foods. Foods investigated include meat products, dairy products, and fruits and vegetables. Significant reductions of microbial load (> 99 %) were achieved in studies, with quality parameters remaining unaffected. While these results are promising, further studies investigating the inactivation capabilities of LEDs on solid foods should be carried out to determine suitable treatments and investigate the possible effects of UV-LEDs on food quality.

These results show that this technology can be effective in inactivating food spoilage microorganisms in solid foods and therefore has potential as a food decontamination tool in the food industry.

The application of UV light for liquid food non-thermal pasteurisation has been widely studied. However, the applications of UV-LED for safety purposes are, again, limited. Teagasc researchers have recently published a study investigating the effect of various UV-LED treatments on food spoilage bacteria (*B. subtilis*) in different food mediums and reported reductions of over 99.9 % and 99.9999 % in model 1 (nutrient broth) and model 2 (peptone buffered saline), respectively. In addition, post-treatment monitoring was carried out for a duration of 18 hours (Hinds *et al.*, 2019). Further research was carried out for solid dried food ingredients. Black pepper samples inoculated with *B. subtilis* were subjected to various UV treatments and reductions of > 90 % were achieved (**Figure 1**). These results show that this technology can be effective in inactivating food spoilage microorganisms in solid foods and therefore has potential as a food decontamination tool in the food industry.

Advantages of UV-LEDs

UV-LEDs offer multiple practical benefits over commercial UV sources, such as zero toxic waste generation, longer life span, compact and robust design, no warm-up time and lower heat emissions. More significantly, UV-LEDs are commercially available at multiple wavelengths and therefore offer the capability to design customised UV reactors. However, while the semiconductor industry is making tremendous advances, there are still some issues with low efficiencies at lower UV wavelengths, which will need to be addressed.

Acknowledgement

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References

Hinds, L.M., Charoux, C.M.G., Akhter, M., O'Donnell, C.P. and Tiwari, B.K. (2019). 'Effectiveness of a novel UV light emitting diode based technology for the microbial inactivation of *Bacillus subtilis* in model food systems.' *Food Control*: 106910.

Hinds, L.M., O'Donnell, C.P., Akhter, M. and Tiwari B.K. (2019). 'Principles and mechanisms of ultraviolet light emitting diode technology for food industry applications.' *Innovative Food Science & Emerging Technologies* 56: 102153.

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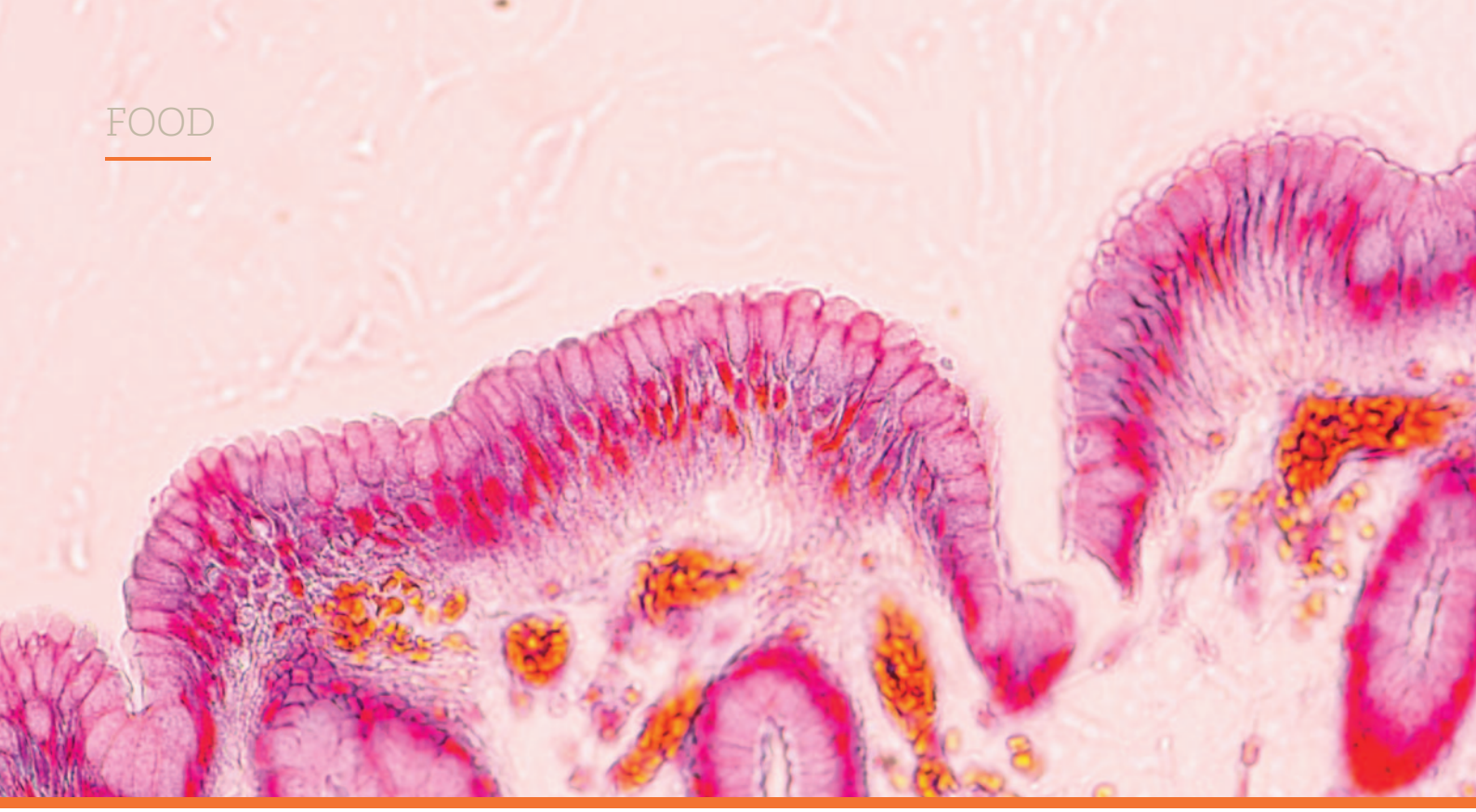

The project investigates gastro-intestinal digestion in the infant gut using in vitro *models.*

A gentler approach to making infant formula

TEAGASC and Cork Institute of Technology researchers are investigating ways to improve infant formula manufacture through gentle processing.

At present, 10-12 % of the entire global infant formula (IF) market is manufactured in Ireland. This is an important export product. IF usually undergoes high heat treatment to ensure safety and long shelf life, but there is scope to improve its nutritional quality. For example, heat treatment denatures proteins, and causes proteins to aggregate and interact with sugars to form various by-products.

Our project, entitled Thermal Or Membrane processing for Infant formula (TOMI), aims to produce IF by cascade membrane filtration. This will reduce heat treatments to harness the health benefit of dairy proteins in their natural state. The new formula will be tested for microbial and chemical safety. We will also follow the fate of proteins during gastro-intestinal digestion in the infant gut using *in vitro* models, allowing us to compare the health benefits of our new formulation to standard IF. TOMI has the potential to radically improve the quality of IF produced in Ireland.

Manufacture of cascade membrane infant formula

Cascade membrane IF (C-IF) production differs from standard IF manufacturing, in that it involves a split stream processing step. The protein component is processed as a parallel but separate stream to the other components (lactose, fat, minerals). The protein stream is processed using membrane filtration, while the remaining components are processed using standard heat treatment, and the two streams are recombined to give the final product. At the Teagasc Moorepark pilot plant (**Figure 1**), C-IF was manufactured and the product compared to a standard IF manufactured in the same facility. The removal of a heat step and the characteristics of the membrane-filtered protein stream resulted in a different product to standard formula. These characteristics included a different protein profile, more native proteins, and reduced potential for thermally induced degradation products.

Proteins in cascade membrane infant formula

When we compared C-IF powder to standard heat-treated IF, C-IF powder contained eight-fold more native whey proteins. The state of protein aggregation also differs, where the more gentle membrane filtration results in fewer aggregated proteins compared to heat treatment. In addition, it was shown that low-heat treatment can retain the native structure and activity of some indigenous enzymes, which may exhibit added health benefits. To investigate the potential health benefits of the altered protein profile, the standard and C-IF powders were subjected to a simulated gastro-intestinal digestion mimicking the infant gut. The rate of digestion of the proteins appeared to differ between C-IF and standard IF, with intact whey proteins taking longer to digest in the gastric phase in C-IF powder. At Teagasc, human intestinal barrier models (Caco-2 monolayers) were cultured and differentiated in transwell plates over 21 days. Exposing these monolayers to digested IF samples reduced barrier integrity. In

particular, standard IF post digestion significantly decreased transepithelial electrical resistance (TEER) values compared to C-IF ($P < 0.05$). This may indicate that IF produced by cascade membrane filtration can promote a healthier gut barrier.

The new formula will be tested for microbial and chemical safety. We will also follow the fate of proteins during gastro-intestinal digestion in the infant gut using *in vitro* models, allowing us to compare the health benefits of our new formulation to standard IF.

Microbial and chemical safety of cascade membrane infant formula

In Cork Institute of Technology, the microbial safety of the pilot scale process was assessed by standard plating methods. No significant differences in the microbial quality of the final powder products produced by standard and membrane processing were identified. However, additional work detailing the microbial profile of C-IF using state-of-the-art molecular analysis is ongoing. Advanced glycation end products (AGEs) are non-enzymatic by-products formed when sugars and proteins are heated together. Scientific studies are inconclusive regarding negative effects of AGEs formed in milk products, but the general impression is that AGEs are not naturally present in milks and should not, therefore, be in infant formula. Recent microbial contamination issues have pushed IF manufacturers to resort to more extreme heat treatments, increasing the potential for AGE formation. The levels of a characteristic AGE, carboxymethyl lysine, were determined in standard IF and C-IF, using an ELISA kit. Significantly lower levels of carboxymethyl lysine were observed for the C-IF compared to standard IF. These results are encouraging, but to increase data accuracy and investigate other AGEs, high-performance liquid chromatography and mass spectrometry (HPLC MS/MS) instrumentation is required. As such, we have initiated a collaboration with Prof. Mike Davies at the University of Copenhagen, Denmark, to quantify levels of these compounds on day one of manufacture, three months later (shelf life), and to investigate what happens to these compounds during gastro-intestinal digestion in the infant gut model.

Innovation in IF

IF constitutes a particularly sensitive food product given the vulnerability of the target population. Therefore, the benefits of any innovation must clearly outweigh any risk involved in change management. The TOMI project has demonstrated that C-IF will provide a product with an alternative native protein profile, reduced AGEs and indicated positive effects on the intestinal cells. Additional work is required to quantify these benefits and confirm that the alternative manufacturing process will provide a significantly improved IF.

The Teagasc Moorepark pilot plant.

Acknowledgements

This work was funded by the Department of Agriculture, Food and the Marine (FIRM Grant No. 15/F/604 TOMI). Yihong Chen is in receipt of a Teagasc Walsh Fellowship. The experimental work was undertaken by postdoctoral scientist Simona Bavaro (Teagasc) and PhD students Colm Shanahan (CIT) and Yihong Chen (Teagasc). Future work will include a preclinical (pig) trial at the Pig Development Department (Teagasc) under the direction of Peadar Lawlor.

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Does terroir exist for whiskey?

Eddie Harpur's farm, Bannow Island, Co. Wexford (photo by Caolan Barron).

TEAGASC research is investigating whether a terroir effect could influence the quality of Irish whiskey.

Irish whiskey (uisce beatha Eireannach) is one of the oldest spirit drinks in Europe and is a geographical indication product approved by the EU, which is a designation used to identify a product whose quality and reputation is linked to its geographical origin. Whiskey is produced from a mash of malted cereals, with or without whole grains of other cereals. The general classification 'Irish whiskey/uisce beatha Eireannach/Irish whisky' contains three categories: 'pot still Irish whiskey/Irish pot still whiskey', 'malt Irish whiskey/Irish malt whiskey', and 'grain Irish whiskey/Irish grain whiskey', which can also be combined to form a 'blended Irish whiskey/Irish blended whiskey'.

Whiskey production

Malting is defined as the controlled germination of cereals, which prepares the starch to be converted into fermentable sugars. The malt is mixed with hot water (mashing) to allow the starch to be converted into sugar by natural enzymes. After the separation of the grains, the sweet sugary liquid remaining is known as wort. The wort is subsequently fermented by yeast and the sugars are converted to alcohols.

During the fermentation process a high number of volatiles are produced, and the final fermented liquid is known as the wash.

The wash is distilled in either pot stills or column stills. The first stage distillate is termed 'low wines' (LW), with an alcoholic strength by volume (ABV) of ~20/25 %. The next distillation occurs in the spirit still and different fractions are collected via condensation; the first and third are called foreshots and feints, respectively, and are recycled back to the LW.

The middle cut is collected until the alcohol content is reduced to ~60 % ABV in the spirit (S). The S may be double or triple distilled, according to the choice of individual distilleries, and the final alcoholic strength must be no more than 94.8 %. The alcoholic content is reduced with water to 63-70 % before maturation process.

The maturation of the final distillate occurs for at least three years in oak casks with a capacity not exceeding 700 L, which in some cases have been previously used to store other alcoholic beverages. The final Irish whiskey has a minimum alcohol content of 40 % ABV. Natural caramel colouring (E150) is permitted but not always used. The colour of whiskey ranges from pale gold to dark amber, and its aroma and flavour become more complex due to the large amount of odour-active chemical classes produced during the process.

Terroir effect

Although each step of the distilling process plays a vital role in establishing the flavour complexity of the whiskey, the cereal crop imparts a distinctive sensory profile, which is allegedly directly attributable to its geographical origin and therefore may impart a terroir aspect to whiskey.

Terroir is the set of all environmental factors that affect a crop's phenotype, including unique environment contexts, farming practices and a crop's specific growth habitat. Collectively, these contextual characteristics are said to have a character and the term terroir refers to this character. Terroir forms the basis of the French wine appellation d'origine contrôlée (AOC) system, which is a model for wine appellation and regulation in France and around the world. However, terroir has not been established for whiskey, and it is not clear if distillation enhances or reduces potential effects. Recent studies have linked barley genotype to beer flavour and composition (Herb *et al.*, 2017; Bettenhausen, *et al.*, 2018), highlighting a

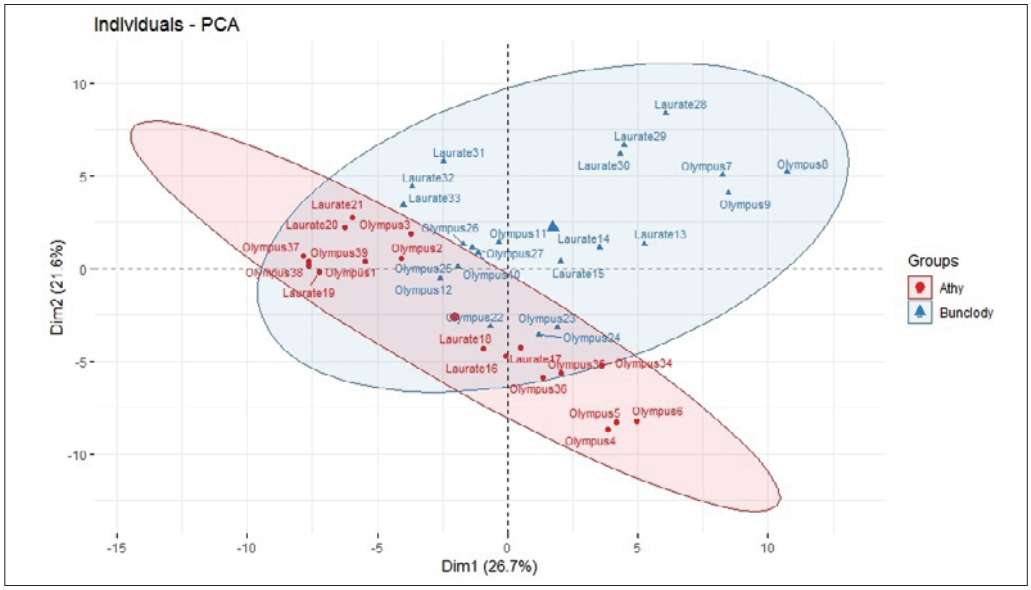

FIGURE 1: PCA plot and groups of spirits according to the origin of the barley (location).

potential terroir impact for the brewing industry, suggesting a possibility for whiskey.

Enterprise Ireland, through the Innovation Partnership Programme, has funded a project with Waterford Distillery and Teagasc to investigate the potential of terroir in Irish whiskey distillates. A multivariate statistical approach is used to determine the impact of volatiles arising from the phenotypic expression of barley produced at different geographical locations that may impact on the sensory characteristics of the resulting distillates.

Enterprise Ireland, through the Innovation Partnership Programme, has funded a project with Waterford Distillery and Teagasc to investigate the potential of terroir in Irish whiskey distillates.

Experimental design

During this experiment, barley from two varieties (Olympus and Laureate), and at two distinct locations (Athy, Co. Kildare, and Bunclody, Co. Wexford) was harvested, processed, malted and fermented. Micro-distillations were undertaken and samples from different stages of whiskey production (LW, S, foreshots and feints) were collected.

The volatile profiles of the samples were investigated using head space solid phase micro-extraction gas chromatography mass spectrometry (HS-SPME GCMS). The statistical analysis of the results was undertaken using principal component analysis (PCA).

Results

A total of 78 volatile compounds were identified in preliminary LW and S samples. Esters were the most common flavour chemical class and they also had the most significant contribution to the differentiations among the treatments. PCA plots were generated to evaluate the variation and the possible effect among the volatile profiles of the samples. **Figure 1** is a PCA biplot of S samples produced from both barley types (Olympus and Laureate) from both sites (Athy and Bunclody). It is apparent that a greater discrimination exists for location than for barley variety, which seems to imply that terroir may be a factor in Irish whiskey. Further studies are ongoing.

Acknowledgements

This work was funded by EI Contract No: IP 2018 0733. Waterford Distillery (Grattan Quay, Waterford City, Ireland), Boortmalt Ireland (Minch Malt Limited, The Maltings, Athy, County Kildare, Ireland), Tatlock & Thomson (Tatlock House, The Teuchats, By Leven, Fife, KY8 5PF, Scotland), and Dustin Herb (Oregon State University, Corvallis, Oregon, USA) are also acknowledged.

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Clean and green

TEAGASC is collaborating in international research into how disruptive technologies can be used to extract hydrocolloids from Irish seaweeds.

Hydrocolloids from seaweeds

Hydrocolloids (e.g., agar and alginate) are substances that form gels or provide viscous dispersion in water, and are found in the cell wall of seaweeds. Seaweeds are known for a range of food applications and for their multiple biological properties, including antibacterial, antioxidative, anti-inflammatory, antitumour and antiviral. From an industrial application point of view, hydrocolloids exhibit the ability to be employed as gelling, stabilising, thickening and emulsifying agents, or for water-holding purposes. Among all the polysaccharides present in seaweeds, agar and alginate are two of the most commercialised compounds. Red seaweed species (i.e., *Gelidium sesquipedale*, *Gelidium amansii*) are commonly used for agar extraction since sulfated galactans (e.g., agar and carrageenan) are the most abundant compounds in the cell walls. The most common brown seaweed species for alginate extraction commonly found in Ireland is *Ascophyllum nodosum*, whereas other species include *Durvillaea*, *Ecklonia*, *Laminaria*, *Lessonia*, *Macrocystis* and *Sargassum*. Alginate and agar extracted from seaweeds have also been used to form biodegradable polymer films, which are food safe, recyclable and suitable for biological use. Nevertheless, this application is still under research and relies on the efficiency of methods of extraction of these biomaterials from seaweeds.

Extraction approaches

Conventional extraction processes of agar and alginate are time consuming and are not sustainable due to high usage of chemical solvents (**Figure 1**). During the extraction processes, the harsh conditions created disrupt the matrices of the seaweed cell wall in order to free the targeted chemical compounds into the extraction medium. Non-environmentally friendly wastes are also generated during the purification processes. Therefore, there is an increasing interest in more efficient and greener extraction approaches for hydrocolloids. Researchers at Teagasc, in collaboration with other European research bodies (IATA-CSIC, Spain; Hohenheim University, Germany; RISE, Sweden; and, Nofima, Norway) are investigating the application of novel extraction technologies to produce agar and alginates for the agri-food sector as a part of the BIOCARB-4-Food project (www.biocarb4food.eu).

Novel extraction technologies

Novel extraction techniques (e.g., ultrasound-assisted extraction (UAE), microwave-assisted extraction (MAE) and enzyme-assisted extraction (EAE)) are based on different mechanisms to affect the solubility of the desired compounds or to modify the seaweed cell wall in order to shorten extraction time and enhance yields. UAE is based on the acoustic cavitation phenomena. It can disrupt the cell wall totally or partially by collapsing bubbles that hit the surface of the seaweed particles. MAE is based on microwave radiation that heats up the inner water of the cell walls, giving a rise in the intracellular pressure to break down the cell wall internally and then

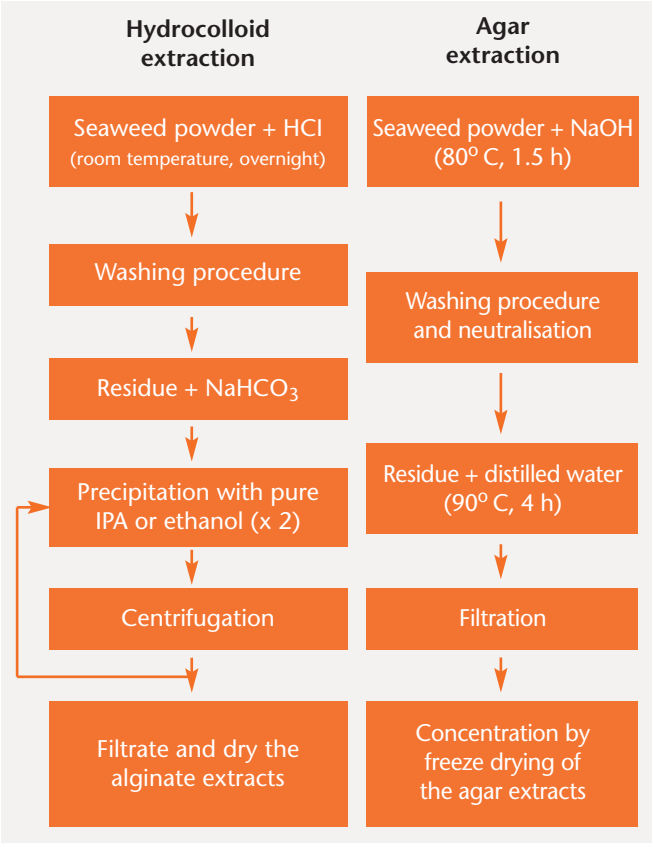

FIGURE 1: Schematics of conventional alginate and agar extraction.

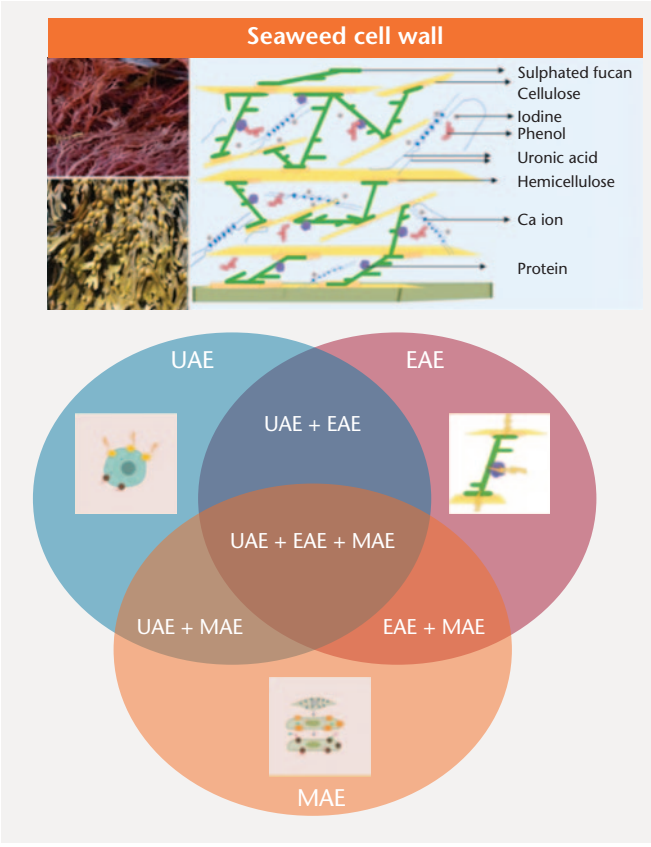

FIGURE 2: The combined novel techniques for hydrocolloid extraction.

release the inner compounds of the cell wall. EAE consists of the addition of enzymes such as carbohydrase (e.g., cellulase, pectinase, β-glucosidase, xylanase, β-glucanase, etc.) to hydrolyse the cellulose and hemicellulose structures in the cell wall and therefore modify the nature of the cell wall. EAE is also a green technique using enzymatic hydrolysis processes to replace the role of organic solvents used in extraction.

The most common lab-scale set-up for UAE is using ultrasonic probes (20 kHz and 500 W), where the transducer is directly in contact with the medium. A temperature control system is frequently employed to avoid thermal degradation of some valuable compounds (e.g., polyphenols, vitamins, proteins and fatty acids). However, for some heat-dependable extractions of agar and alginate, synergism of heat generated from MAE and the acoustic function of an ultrasound system can cause cavitation on the cell wall, which works more effectively than just relying on one individual technique.

Microwave at 2.5 GHz with a power of 400-2,000 W is used to fasten the heat treatment and to accelerate mass transfer during extraction. Both UAE and MAE can also be employed for the purpose of pre-treatment to degrade the cell wall polysaccharides and to release some active compounds such as phlorotannins, which have been found to form complexes with proteins. Thus, protease-assisted extraction (e.g., alcalase, neutrase, papain) can also take place to disrupt the cell wall structure. EAE is carried out under controlled temperature (~ 50° C) while UAE is supposed to couple the process to reduce extraction time and maximise yield. At the end of an EAE process, MAE can be involved to increase the temperature up to ca. 90° C in order to ease up all enzymatic functions. In this way, the potential of these extraction techniques for hydrocolloids can be exploited and it is possible to upscale these techniques, enabling their usage for large-scale industrial production (**Figure 2**).

Acknowledgements

The authors are grateful for funding from the Department of Agriculture, Food and the Marine for the ERA-NET Cofund on Sustainable Food Production and Consumption – SUSFOOD2 'BIOCARB-4-FOOD' project call by the consortium formed by IATA-CSIC, Nofima, Teagasc, the University of Hohenheim and RISE.

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Outlook 2020

The TEAGASC Outlook 2020 review reports that lower production costs and exceptional aid is prompting a gradual recovery in farm incomes.

Teagasc estimates that the average family farm income in Ireland increased by an estimated 7 % in 2019. This finding was included in Outlook 2020, the annual review and outlook of agriculture prepared by Teagasc economists, which was published in November 2019.

A key driver of this 2019 income increase has been a reduction in animal feed use on dairy, beef and sheep farms, as well as additional subsidy supports in the form of exceptional aid measures (BEAM and BEEP schemes*) channelled to cattle producers to alleviate the effects of falling beef prices.

While farming in 2018 was dominated by unfavourable weather, production conditions returned to normal for 2019. This led to a substantial reduction in animal feed expenditure by dairy, beef and sheep farmers.

There were also cost savings due to lower fertiliser use, as well as lower spending on silage production in 2019. However, price increases for animal feed and fertiliser in 2019 partially offset the cost savings relating to lower input usage.

The volume of milk and cereals produced in Ireland increased in 2019. The production of beef and sheep has been disrupted by the recent blockade of meat factories, which ended shortly after the publication of the Irish beef sector agreement in September 2019. In the year to the end of November 2019, the throughput of cattle and sheep was well behind the previous year, but higher slaughter levels in the last quarter of 2019 should partially offset the drop in beef and sheep output volumes arising from the blockade.

The African swine fever (ASF) outbreak in China has resulted in a sharp increase in international pig prices, including in Ireland, returning the Irish pig sector to profitability in 2019. However, prices for milk, beef and sheep were all lower in Ireland in 2019 compared to 2018.

Farming sector incomes – 2019

Looking across the farming sectors, average incomes on dairy farms have increased in 2019, benefitting from lower production costs and a further increase in milk production. Incomes are estimated to have increased by 14 % on average on dairy farms. By contrast, incomes on tillage farms in 2019 are estimated to have fallen considerably, down on average 24 %, due to a sharp drop in cereal prices.

Incomes on beef farms are estimated to have risen by about 10 % in 2019, largely due to the exceptional aid made available to offset falling beef prices in the fourth quarter of 2018 and the first quarter of 2019, and lower spending on inputs in 2019 as compared to 2018. Despite substantially lower marketed output values, incomes on specialist sheep farms are also estimated to be up in 2019, largely due to receipt of exceptional aid pertaining to beef animals on these farms and also receipt of the Sheep Welfare Scheme. The average income on sheep farms is estimated to have increased by 4 % in 2019. Family farm income estimates for 2019 for each farming system are illustrated in **Figure 1**.

Outlook for 2020

Looking ahead to 2020, a further improvement in average family farm incomes is in prospect. This is conditional on the assumption that normal weather prevails. The expansion in Irish milk production is expected to continue. In 2020 average Irish milk prices are likely to remain similar to the 2019 average.

The increase in fertiliser and cattle and sheep feed prices in 2019 is set to reverse in 2020, leading to a slight drop in production costs across grassland and tillage farms. Feed prices are forecast to decline by about 5 % in 2020 for the year as a whole, while fertiliser prices are forecast to decline by about 7 % in 2020, with no change in fertiliser volume anticipated.

Cattle and cereal prices are forecast to improve slightly in 2020,

Summary of 2019

Output prices
Lower for milk, beef, lamb, cereals
Higher for pigs

Output volume
Milk, cereals up
Cattle, sheep down

Output value
Total output value down

Inputs
Prices increase for feed and fertiliser, but fuel prices down
Use of feed and fertiliser down

Average income estimate for 2019 +7 %

Summary of 2020

Output prices
Stable for milk and lamb
Up for cattle, cereals and pigs

Output volume
Volume to increase for milk, sheep and pigs
Stable for cattle, cereals

Output value
Total output value up

Inputs
Price drops for feed and fertiliser
Volumes to remain stable

Average income forecast for 2020 +7 %

while milk and lamb prices are likely to remain relatively stable for the year as a whole. While pig feed prices are set to rise slightly in 2020, this will be more than offset by a substantial increase in pig prices, due to the continued fallout from ASF in Asia.

Family farm income

A wide disparity in average income levels exists across the various farm systems and there is considerable variation in income levels within each system type. Dairy and tillage farms are typically located in areas with superior soil and climatic conditions and are, on average, much larger than other farm types. As a result, dairy and tillage farms continue to generate average incomes on a per farm basis that are substantially higher than the average income on beef and sheep farms. Family farm incomes are forecast to increase in 2020 on dairy, tillage and sheep farms, with minor changes in income forecast for cattle farms. Overall, the average family farm income is forecast to rise by 7 % in 2020.

Acknowledgements

Emma Dillon, Kevin Hanrahan, Tom Houlihan, Jason Loughrey, Michael McKeon, Brian Moran, and Fiona Thorne.

References

Dillon, E., Donnellan, T., Hanrahan, K., Houlihan, T., Kinsella, A., Loughrey, J., McKeon, M., Moran, B., Thorne, F. (2019). 'Outlook 2020, Economic Prospects for Agriculture.'

Further information on the Teagasc Outlook 2020, Economic Prospects for Agriculture, is available at www.teagasc.ie/media/website/publications/2019/Outlook_2020.pdf.

**BEAM – Beef Exceptional Aid Measure; BEEP – Beef Environmental Efficiency Pilot.*

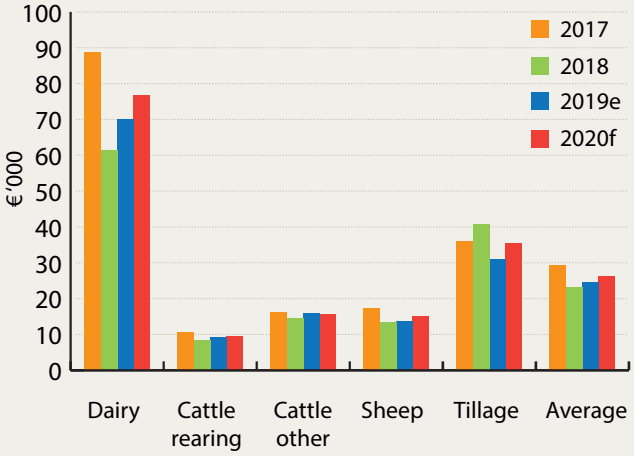

FIGURE 1: Average income levels per farm system in 2017 and 2018, with an estimate for 2019 and a forecast for 2020. Source: Teagasc National Farm Survey and authors' estimates. Note: 2019e (estimate), 2020f (forecast).

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Africa and beyond through the *agri benchmark* lens

TEAGASC was represented at the recent *agri benchmark* conference in Namibia, where livestock production issues in Africa were placed in a global context.

Africa's population is predicted to grow from its current 1.2 billion to over 2.5 billion people by 2050. This population explosion will put African livestock producers under pressure to increase production and productivity to meet growing demand.

Central role of livestock in African society

Research from the United Nations' Food and Agriculture Organisation (FAO) indicates that 62% of rural African households keep livestock. In certain societies keeping livestock encourages women's empowerment and, by 2015, it could ensure the creation of 800 million jobs. However, increased competition among farmers for productive resources may lead to a potential mass exodus from the industry.

Speaking at the 2019 annual *agri benchmark* beef and sheep conference, which was held in Namibia, Ugo Pica-Ciamarra, a livestock economist in the animal production and health division of the FAO, said that "exponential transformation is expected over the next three decades, which will undoubtedly pose huge challenges to societies. In order to be sustainable and profitable, the continent and its livestock industry must adapt and keep up with modern technology and farming practices. This is why more and more individuals will move from rural to urban areas in search of job opportunities. In turn, this will bring about the decline of rural economies".

agri benchmark

During the conference, field trips to farms highlighted issues affecting farming in already difficult climatic conditions, accelerated by the most severe drought of the past hundred years. A special focus of this international event was on agricultural development, with workshop topics including the costs of predators and other impacts on livestock production, particularly in the southern African context.

A forthcoming report from the conference provides an overview of the most important developments in the global beef and sheep sectors in 2018/2019. The economic analysis undertaken at farm level comprises price developments and benchmarking results from the *agri benchmark* international database.

The global picture – beef consumption and production

In the last decade, global beef production and consumption have increased. Per capita (p.c.) beef consumption and its development in the countries participating in the *agri benchmark* Beef and Sheep Network are shown in **Figure 1**. Consumption patterns show significant differences, with the chart on the left illustrating the countries with a decrease in consumption in 2017 compared to 2002. Particularly strong decreases are observed in OECD countries, but also in Namibia, Ukraine, and to some extent in Argentina. In Australia and the US, the decrease in domestic consumption means that more production has now to be exported. In the EU, decreasing consumption is mirrored by decreasing production. The chart on the right hand side shows the countries with an increase in p.c. consumption. Uruguay, together with Argentina, has the highest p.c. consumption. Some emerging economies like Brazil and South

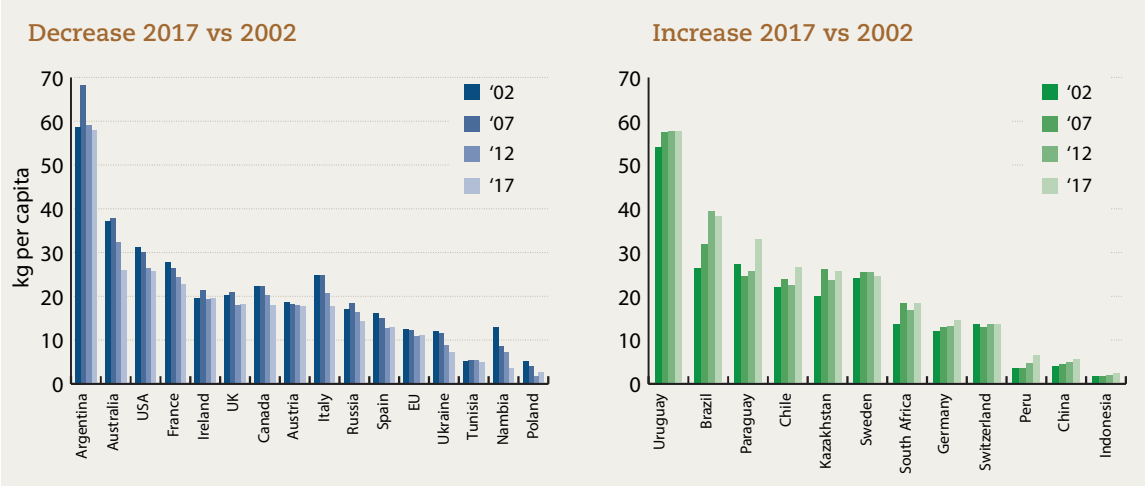

FIGURE 1: Per capita consumption of beef in selected countries 2002-2017 (kg per capita and year). Source: agri benchmark, *national statistics.*

Africa also show p.c. increases. The strong increase in p.c. consumption in Brazil, China and Indonesia, coupled with the larger populations in these countries, means a significant increase in total consumption.

The top 10 cattle meat trade flows in 2017 are shown in **Figure 2**. Most of the top 10 trade flows have not changed in the last three years, but there is one new entry: buffalo meat (carabeef) from India to Vietnam. Exports from Australia and New Zealand to the US are mainly ground cattle meat from grass-fed animals, which is mixed with grain-fed cattle meat in the US to make hamburgers. Both the US and Australia compete in the high-value Japanese market. Ireland exports significant quantities of cattle meat to the UK, which is the single most important destination for Irish cattle meat. China has already been a target for Brazilian cattle meat for some years. Uruguay now also exports significant quantities to China, making it into the top 10 trade flows.

Namibia in good standing as beef and sheep producer

When it comes to beef production tonnage, Namibia is ranked 111th in the world and 73rd for sheep. In terms of meat exports it is 32nd for beef and 20th for sheep; for live animal exports 28th for beef and seventh for sheep.

Namibia's traceable and naturally produced meat products, especially beef, are globally regarded to be of exemplary quality. At *agri benchmark*, Claus Deblitz of the Thünen Institute of Farm Economics and co-ordinator of *agri benchmark* Beef and Sheep, stressed that this counts hugely in the country's favour: "Namibia is not a big country, but it hasn't allowed its size to determine its road to success as a livestock producer in a global context. Traceability and an exceptional export sector are just two of the reasons why Namibia has access to some of the most lucrative global markets, such as the EU". However, one area of concern is in addressing low-to-medium productivity statistics in cow-calf farming systems: "This needs to be addressed as soon as possible considering the fact that Namibia is ranked 28th in live cattle exports. Namibia is classified as a world leader in keeping beef production costs to a minimum, with production costs highest in North America and Europe".

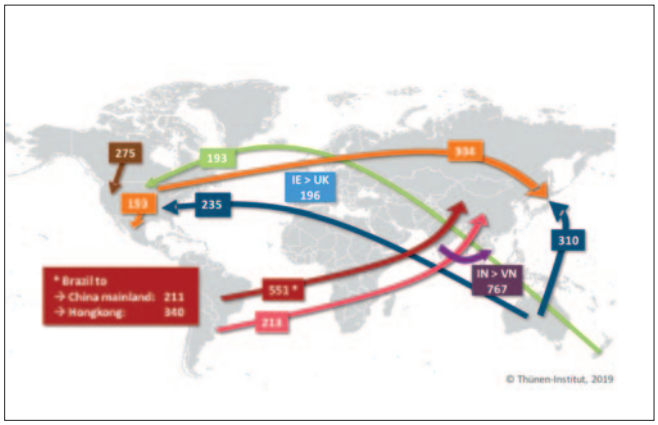

FIGURE 2: Top 10 cattle meat export flows 2017 ('000 tons) – Uruguay is a new player. Source: UNComtrade 09.2019.

References

Deblitz, C. *agri benchmark* Beef and Sheep Report 2019 – a summary. Available from: http://www.agribenchmark.org/home.html
FAOStat: http://www.fao.org/faostat/en/#home
UNComtrade: https://comtrade.un.org/db/default.aspx
Agriforum Agricultural Magazine, August 2019 – https://www.agriforum.com.na

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Animal & Grassland Research and Innovation Programme | Crops, Environment and Land Use Programme | Teagasc Head Office | Food Programme | Rural Economy & Development Programme

JANUARY 2020

January 9-11 *RDS, Dublin*

TEAGASC AT THE BT YOUNG SCIENTIST AND TECHNOLOGY EXHIBITION

Visit the Teagasc stand (W7) in the 'World of Science and Technology', to meet Teagasc research, education and advisory staff and participate in hands-on experiments and activities. The Teagasc prize will be awarded to the student project in the main exhibition area that best demonstrates a thorough understanding of the science of agricultural or food production, or the use of science to improve technologies available to agricultural or food production.

Contact: catriona.boyle@teagasc.ie
http://btyoungscientist.com/

January 15 *Horse and Jockey Hotel, Co. Tipperary*

ONCE-A-DAY MILKING CONFERENCE

Once-a-day milking is sometimes considered as an option on farms where labour is in short supply, where farm layout means long walks for cows to and from the parlour, or simply because reducing the number of milkings is attractive from a lifestyle perspective. The conference includes sessions on farmers' experiences, financial performance, the Teagasc Moorepark once-a-day herd, and a comparison of twice daily, once-a-day or robotic milk production systems. Advance registration is required.

Contact: Brian.Hilliard@teagasc.ie
https://www.teagasc.ie/news--events/

January 28 *Great Southern Hotel, Killarney, Co. Kerry*
January 30 *Springhill Court Hotel, Kilkenny City, Co. Kilkenny*
February 19 *Donegal (Hill Sheep)*

NATIONAL SHEEP CONFERENCES

The annual Teagasc National Sheep Conference brings up-to-date, relevant knowledge to sheep producers to improve flock health. There will be a mixture of Teagasc, international and industry speakers. These are Knowledge Transfer-approved events.

Contact: michael.diskin@teagasc.ie
https://www.teagasc.ie/news--events/

January 29 *Lyrath Convention Centre, Co. Kilkenny*

NATIONAL TILLAGE CONFERENCE 2020

While the tillage sector is the lowest contributor of greenhouse gas emissions in Irish agriculture, the sector faces significant risks posed by the loss of important chemistries for pest/pathogen control and the need to further enhance sustainable practices. In response, the 2020 Tillage Conference will provide up-to-date outputs from research investigating the management of fungal and viral cereal diseases, plus the importance of genetics in breeding more nutrient-efficient/stress-resilient varieties. The role of cover crops will be objectively discussed against the demands of future sustainability goals, as will the rotational options heading into spring 2020. Meanwhile, a specific workshop will see the launch of the next generation Teagasc Crop Report.

Contact: ewen.mullins@teagasc.ie
https://www.teagasc.ie/news--events/

FEBRUARY

February 27-28 *Teagasc Ashtown Food Research Centre, Dublin 15*

ALL-IRELAND MEAT SCIENCE CONFERENCE

Speakers from Ireland and abroad will address issues important to the sustainable growth of the sector, such as innovative packaging solutions, dietary changes, the impact of climate change and the science of meat quality. The conference will be very relevant to scientists, technical staff and all stakeholders working in research, the food industry and relevant Government agencies. A call for abstracts, posters and opportunities to sponsor will follow shortly. Registration is available on Eventbrite.

Contact: declan.troy@teagasc.ie
https://www.teagasc.ie/news--events/

MAY

May 29-30 *Claregalway Castle, Co. Galway*

EUROPEAN CONGRESS MEAT, DAIRY, WOOL

On day one, sector experts will present and discuss the state of play and the future opportunities in farming, food production, wool and its products, agritourism and sustainable practices. On day two, delegates will attend 'Living with Sheep', including an agritourism panel discussion on the importance and future of sheep farm tourism, country festivals and food tours, enjoy the sheep breeds, sheepdog trials, shearing, etc.

Contact: www.projectbaa.com

JUNE

June 10-11 *Radisson Blu Hotel, Little Island, and Teagasc Moorepark, Co. Cork*

PASTURE SUMMIT 2020

This is a biannual event between Ireland and New Zealand. On day one there will be conference sessions with leading scientific, social, business and farming experts from around the world followed by a gala dinner. Interactive workshops on day two take place at Teagasc Moorepark. Delegates will have an option to attend five workshops. The workshops will enable delegates to ask questions and interact with speakers.

Contact: info.pasturesummit@gmail.com
http://www.pasturesummit.ie/

AUGUST

August 17-20 *University College Cork*

8TH INTERNATIONAL CONFERENCE ON THE ASSESSMENT OF ANIMAL WELFARE AT FARM AND GROUP LEVEL

In a time of significant global challenges and changes, improving animal welfare can help in tackling many of these, so the science of animal welfare has a large part to play in helping to attain a sustainable way of living in the future. Communications on any topic related to the assessment of animal welfare are very welcome, particularly those which fall into the following themes: transdisciplinary approaches to measuring animal welfare; back to basics: practical solutions to improve animal welfare; animal health and welfare: interchangeable or interdependent?; the role of animal welfare in addressing global grand challenges; and, humans in the animal welfare loop.

Contact: Wafl2020@abbey.ie https://www.wafl2020.com/

For a full list of Teagasc food industry training events see https://www.teagasc.ie/food/research-and-innovation/research-areas/food-industry-development/.
For presentations from previous Teagasc events see: www.teagasc.ie/publications