

T Research

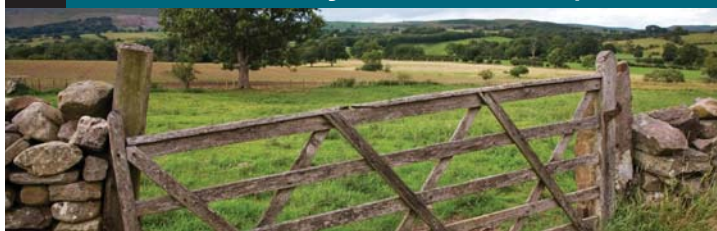
Research and innovation news at Teagasc

Mapping Ireland's soils

- ▶ Bioencapsulation of vaccines
- ▶ Protecting environmental water quality from microbial pathogens
- ▶ Consumer insights: bridging the value gap

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OUR COVER shows a MODIS "true colour" satellite image courtesy of NASA, with an inset showing part of a "false colour" SPOT 5 image.



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

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T Editorial

Rising to the challenge of reduced research funding

Teagasc plays a unique and essential role in developing Ireland's Smart Green Economy given its close relationship with the agri-food sector and its understanding of its needs, on the one hand, and its horizontal integration into university research programmes, on the other. A recent European Commission foresight study has highlighted the importance of this function. It identified the gap between the generation of knowledge and its application within the sector. Teagasc bridges this gap through the generation, transfer and application of knowledge. It is a prerequisite to facilitating our principal indigenous industry to play a significant role in both the economic recovery and the delivery of the Smart Green Economy. The global economic crisis has had a significant impact in Ireland with no sector unprotected. Teagasc has responded rapidly to the deteriorating public finances by initiating the Teagasc Change Programme (2009-2013). Its primary focus has been the restructuring of the organisation and prioritisation of programmes to underpin its essential roles in applied research, knowledge transfer and education. The significant changes are based on a rationalisation and integration of existing Directorates to further exploit the organisation's unique strengths and position in the agri-food sector. The prioritised integrated Programme will focus on: animal production and grassland; crops, environment and land use; food; and, rural economy and development. The outcome will be improved science-based innovation support for our smaller indigenous enterprises in the agri-food sector delivered by applied research and technology transfer, supported by applied scientists and technologists with an intimate knowledge of existing technology and markets. To augment reducing budgets, Teagasc has increased its focus on securing additional external funding, especially from the European Framework Programme 7 (FP7). The aim is to treble our EU funding over the next two years. In 2009, our researchers were significant partners in seven awarded FP7 projects. Teagasc is a significant partner in six proposals submitted in January 2010, and will continue to pursue all potential funding sources to ensure the delivery of its prioritised programmes.



Dr Frank O'Mara
Director of Research

Ag tógáil an dúshláin um maoiniú laghdaithe do thaighde

Glacann Teagasc ról uathúil agus riachtanach i bhforbairt Eacnamaíocht Ghlas Chliste na hÉireann mar gheall ar a dhlúthghaolmhaireacht leis an earnáil agraibhia agus a thuiscint ar a gcuid riachtanais, ar lámh amháin, agus a chomhréimniú cothrománach isteach i gclár thaighde ollscoile, ar an lámh eile. Tá tábhacht na feidhme seo aibhsithe ag staidéar fadfhéachana úrnua Choimisiúin na hEorpa. Shainnadh sé an bhearna idir glúin an eolais agus a chur chun feidhme laistigh den earnáil. Dúnann Teagasc an bhearna seo trí eolas a ghineadh, a aistriú agus a chur chun feidhme. Is réamhriachtanas d'éascú ár bpríomhthionscal dúchasach ról suntastach a imirt san athshlánú eacnamaíocht agus seachadadh na hEacnamaíochta Glais Cliste araon. Tá éifeacht shuntasach ag an ngéarchéim dhomhanda eacnamaíocht ar Éirinn gan aon earnáil gan chosaint. Tá freagairt thapa déanta ag Teagasc ar chúrsaí airgeadais phoiblí tríd an gClár Athraithe Theagaisc a thionscain (2009-2013). Dhirigh sé go háirithe ar athstruchtúrú na heagraíochta agus ar chlár a chur in ord tosaíochta le buntaca a thabhairt dá rólanna riachtanacha i dtaighde feidhmeach, aistriú eolais agus oideachas. Tá na hathruithe suntasacha bunaithe ar réasúnú agus comhtháthú Stiúrthóireachtaí reatha le níos mó úsáide a bhaint as neart uathúil agus suíomh na heagraíochta in earnáil an agraibhia. Díreoidh an clár tosaíochta comhtháite ar: tháirgeadh ainmhithe agus féarhailte; barraí, comhshaol agus úsáid talún; bia; agus, eacnamaíocht tuaithe agus forbairt. Beidh tacaíocht nuála eolaíocht bhunaithe d'ár dtionscnaimh dhúsachasacha níos lú, in earnáil an agraibhia mar thoradh air, á seachadadh ag taighde feidhmeach agus aistriú teicneolaíochta, le tacaíocht ó eolaithe feidhmeacha agus teicneolaithe le dlútheolas ar theicneolaíocht agus margaidh reatha. Chun cur le buiséid laghdaithe, tá fócas Theagaisc méadaithe do mhaoiniú seachtrach breise a fháil, go háirithe ó Chlár 7 Creat na hEorpa (FP7). Is é an aidhm atá leis ár maoiniú AE a mhéadú faoi thrí thar an dá bhliain le teacht. I 2009, bhí ár dtaighdeoirí ina gcomhpháirtithe suntasacha i seacht dtionscnaimh FP7 dámhachtana. Is comhpháirtí suntasach é Teagasc i sé moladh curtha isteach in Eanáir 2010, agus leanfaidh sé ar aghaidh chun foinsí maoinithe poitéinsiúla go léir chun seachadadh a chuid chlár tosaíochta a chinntiú.

Dr Frank O'Mara
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Recent Teagasc research appointments



Dr Padraig French (far left) has been appointed as Head of the new Farm Systems Research Department and the Enterprise Leader for the Animal Production and Grassland Research Centre (APGRC), Moorepark. Dr Michael O'Donovan (left) has been appointed as Head of the new Grassland Science Department at APGRC, Moorepark. Dr Edward O'Riordan (not pictured) has been appointed as Enterprise Leader for APGRC, Grange, and Professor Michael Diskin (not pictured) has been appointed as the new Enterprise Leader for APGRC, Athenry. These new appointments are the near final stages in the process of establishing the integrated Animal Production and Grassland Programme at Teagasc. The new appointees will support Dr Pat Dillon, who leads the programme. This strong new management team will play a very important role in providing leadership in the development of Teagasc's national grass-based agriculture programme.

Climate change since IPCC 4

The Office of the Chief Scientific Adviser to the Government has published *A Survey of Climate Change since IPCC 4*. The review by Professor Ray Bates concluded: "It is frequently stated that the climatic change situation has become much more alarming since the 4th IPCC (Intergovernmental Panel on Climate

Change) Report in 2007. This survey indicates that the underlying trends are continuing: increase in atmospheric CO₂ (+1.62ppm/year); increase in global average temperatures (+0.013 degrees/year); and, rise in sea level (+3.5 mm/year). Natural cyclical changes and normal climate variation superimpose short-term and regional variability on these trends. However, global climate change is real and continuing at a steady pace". For more, see: www.chiefscientificadviser.ie.

Ireland Collection on JSTOR



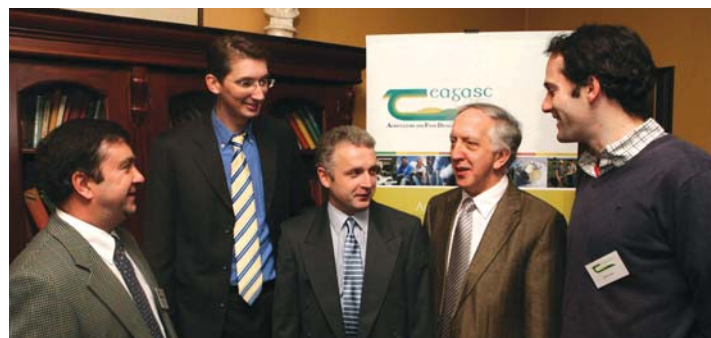
Teagasc has received notification that its peer-reviewed journal, *Irish Journal of Agricultural and Food Research*, was released on JSTOR in December 2009 and will contain the entire collection of back issues of the journal since its inception in 1961.

Teagasc's participation in the Queen's University Belfast/JSTOR digitisation project, which was funded by the JISC Digitisation Programme, gives Teagasc staff free access to the entire 'Ireland Collection', which is accessible via its library website. Access to the Ireland Collection is available without fees to any non-commercial institutions in the Republic of Ireland and the United Kingdom.

According to JSTOR: "The *Irish Journal of Agricultural and Food Research* is a vital part of the collection's resources in the biological sciences".

For more on the Ireland Collection on JSTOR, see <http://www.jstor.org/page/info/publisher-portal>. The journal is now also searchable via Google Scholar.

National tillage conference



Pictured at the Teagasc National Tillage Conference, which took place in Carlow in January are (from left): speakers Dr John Finnan, biofuels researcher; Michael Hennessy, Crops Specialist Adviser; Richie Hackett, tillage researcher; Professor Jimmy Burke, Head of Teagasc Oak Park Crops Research Centre; and, Dr Stephen Kildea, plant pathology researcher.

Rachel Creamer appointed as ESNB chair



Congratulations to Dr Rachel Creamer, Johnstown Castle Environment Research Centre, on her recent election as Chair of the European Soil Bureau Network (ESBN). This network is the European authority on soil research and has representatives from national soil science institutions for all the European member states. Its role is

to advise the European Commission on soil policies through the Joint Research Centre.

The activities of the network include:

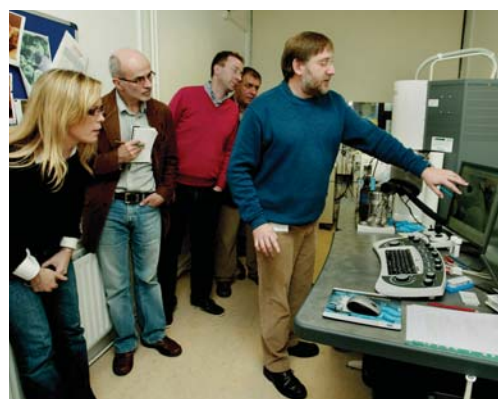
- development of harmonised soil maps across Europe, in compliance with the EU INSPIRE Directive;
- identification of areas in Europe

that are vulnerable to soil threats such as erosion, loss of organic matter, landslides, desertification and salinisation;

- advising the European Commission on soil-related EU policies; and,
- development of a European model for soil education and awareness.

Guild visit

Teagasc Moorepark Research Centre recently hosted the Guild of Agricultural Journalists. The journalists were greeted by Teagasc Director Professor Gerry Boyle, who gave an overview of Teagasc's research programme. The Head of Food Research, Professor Paul Ross, gave the journalists a tour of Moorepark's food research facilities. Dr Pat Dillon, Head of Animal Production and Grassland Research, led a tour of the Animal Production and Grassland Research Centre.



Pictured during the visit are (from left): Margaret Donnelly, Editor of the Irish Farmer's Monthly and Chairperson of the Guild; Stephen Cadogan, Farming Examiner; Pat O'Keeffe, Irish Farmer's Journal; and, Kieran O'Connor, Glanbia. Dr Mark Auty explains food microstructure analysis.

Greenfield dairy site



Jenny Jago, Teagasc Animal Production and Grassland Research Centre, Moorepark, addresses farmers at the Teagasc open day on the Greenfield Dairy Farm in County Kilkenny. The main objective of this farm is to demonstrate best practice in the design, construction and operation of a low cost grass-based milk production system to Irish dairy farmers within the constraints of commercial farm practice. The new dairy demonstration farm is a collaborative project between Teagasc, Glanbia, Agricultural Trust (Irish Farmers Journal), FBD Trust, AIB and the Phelan family (farm owners).

GMSAFOOD project

Scientists in Austria, Ireland, Norway, Hungary, Turkey and Australia have established a consortium to study the influence of genetically modified (GM) foods on health and well-being. The newly established consortium, GMSAFOOD (pronounced, GM-safe-food) will focus on developing biomarkers that could be followed after the release of a GM food on the market. Dr Michelle Epstein at the Medical University of Vienna, Austria, the co-ordinator of the European Commission, Framework 7 project, emphasises that this project addresses GM food safety:

"The function of post market monitoring is to further assess possible nutritional and health effects of GM foods on a mixed population of consumers. Currently, however, little is known about exposure levels, whether adverse effects are



Microbiological analysis of faecal and digesta samples being carried out as part of GMSAFOOD.

predictable, and the occurrence of any unexpected effects following market release of GM foods. Thus, monitoring during the post market period is essential for effective surveillance. The objective of the three-year European Commission-funded project is to identify a panel of biomarkers, which could be used to predict harmful GM food effects after product authorisation".

The pig is one of the animal models to be used in this project and this component of the project is led by Dr Peadar Lawlor of the Teagasc Pig Development Unit, Teagasc Animal Production and Grassland Research Centre, Moorepark. Other

members of the Irish team include Dr Maria Walsh, Stefan Buzoianu DVM, Professor Paul Ross and Dr Mary Rea, all of Teagasc, and Dr Gillian Gardiner of Waterford Institute of Technology. For more, see: www.gmsafood.org.

Highly accessed paper

A paper by Teagasc researchers has been designated as 'Highly Accessed' by Biomed Central. The paper was published in BMC Veterinary Research, 5:36. 'Temporal patterns of inflammatory gene expression in local tissues after banding or burdizzo castration in cattle'

Wanyong Pang, Bernadette Earley, Torres Sweeney, Vivian Gath and Mark A Crowe. Corresponding Author: Bernadette Earley, Animal Production and Grassland Research Centre, Grange, E-mail: bernadette.earley@teagasc.ie. The paper can be accessed at www.biomedcentral.com/1746-6148/5/36.

Concern CE elected to CGIAR

The Chief Executive of Concern Worldwide, Tom Arnold, is one of two members from Europe on a nine-member board appointed by the Consultative Group for International Agricultural Research (CGIAR). His appointment follows an international selection, which attracted over 500 nominations.

CGIAR employs more than 8,000 scientists and support staff in over 100 countries. It is involved in cutting edge research aimed at increasing agricultural growth, improving human nutrition and health, and better management of natural resources. The new international board is part of a major reform process of the CGIAR system geared towards maximising the impact of this research on food security and poverty reduction in developing countries.

Researcher profile



Dr Paul Crosson

Dr Paul Crosson is a Research Officer at Teagasc, Animal Production and Grassland Research Centre, Grange, Dunsany, Co Meath, where he is working as a beef systems modeller. The objective of the systems analysis and modelling programme at Grange is: to identify and describe systems of beef production that are technically, financially and labour efficient, and environmentally sustainable;

to indicate the pros and cons of alternatives; to provide benchmarks for sustainable production; and, to analyse the implications of changes in the policy/market environment. The overall aim of this research programme is to provide farmers with the information to enable them to make informed decisions about the systems of production that best suit their business objectives and specific set of circumstances. Paul graduated from University College Dublin in 2001 with a BAgSc (Eng Tech). From 2001 to 2005 he was a Teagasc Walsh Fellow at Teagasc, Animal Production and Grassland Research Centre, Grange/University College Dublin, completing his PhD (Agriculture) on 'The development of a mathematical model to investigate Irish beef production systems'.

From September 2004 to September 2005 he worked as a visiting researcher at the Pasture Systems and Watershed Management Research Unit, a USDA research centre based at Pennsylvania State University/USDA. While there, his research involved: (i) comparison and validation of Irish beef production systems models; (ii) the linking of production and environmental models; and, (iii) simulation modelling of production options for Maryland beef farming systems. From February 2006 to March 2007 he was a post-doctoral researcher at Teagasc, Animal Production and Grassland Research Centre, Moorepark, Fermoy, Co Cork, where his research involved the development of a bioeconomic stochastic simulation model of Irish suckler beef systems. He joined the team at Grange in March 2007.

Paul has published on a wide range of topics, including: 'The development of a whole farm model to investigate beef production systems'; 'Optimal beef production systems in differing concentrate price and grass utilisation scenarios'; and, 'Bioeconomic modelling of pasture responses to nitrogen fertiliser on the financial performance of suckler beef systems'.

Coming from a farming background in Co Cavan, Paul was interested in a career in agriculture from an early age. He is also interested in all sports, particularly football and soccer, and in film and travel. He is a Council member of the Irish Grassland Association (IGA) and is currently Chair of the beef committee.

The French connection

A joint proposal under the ULYSSES programme funded by IRCSET and the French agency Agide has been submitted to facilitate researcher exchange between the soil molecular ecology units at Johnstown Castle Environment Research Centre and L'Institut National de la Recherche Agronomique (INRA) in Dijon. The two partners are also involved in a FP7 proposal on soil biodiversity, which, if funded, would further enhance the collaboration. Studies in Dijon have shown that in soil under grazed pasture, the functional genes involved in denitrification show distinct patterns related to grazing pressure. Teagasc researchers Fiona Brennan and Bryan Griffiths hope to confirm and advance from these observations and recently visited the labs of Laurent Philippot and Philippe Lemanceau in Dijon. Laurent has generously agreed to provide cultures of the organisms necessary for quantification of functional genes involved in denitrification.

Dairy sector technology expertise

RELAY, the national dissemination service for communicating the results of publicly funded food research to the Irish food industry, has published the third technology and expertise alert for the dairy sector.

The document highlights the technology and expertise as well as the facilities, equipment, services and key contacts at Irish institutes and universities, with the aim of helping companies quickly identify who can help them with R&D/technical challenges, and where the relevant expertise and equipment is available. See www.relayresearch.ie.

Teagasc Gold Medal



Pictured are (from left): Professor Gerry Boyle, Teagasc Director; Dr Paul Cusack, Teagasc Gold Medal recipient; and, Dr Noel Cawley, Teagasc Chairman.

The 2009 recipient of the Teagasc Gold Medal is Dr Paul Cusack, Principal of the College of Amenity Horticulture at the National Botanic Gardens in Dublin. The Teagasc Gold Medal is awarded on an annual basis to a serving staff member who has made an outstanding contribution in his/her particular field.

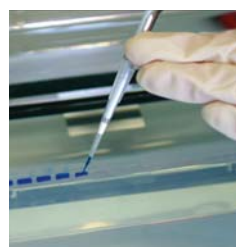
The award was presented to Dr Cusack in recognition of the significant contribution that he has made to horticultural education in Ireland over a long number of years and of the many innovative initiatives he pioneered in horticultural education and training. Under his stewardship, the College of Amenity Horticulture has developed from being a single course institution, with three staff members and 45 students, to its present day status with 27 staff members offering a wide range of courses to a student population of around 400. Dr Cusack has successfully promoted the college to secure a very high reputation in the horticultural world for the quality of its graduates. The award also recognises the considerable managerial skills he has shown in managing the College effectively through an ever-changing environment.

Specialist technical services

Specialist services of interest to the food industry have been launched recently based on technologies that have been developed at Teagasc Ashtown Food Research Centre.

Blown pack spoilage testing service (T-Bio™)

Background



Blown pack spoilage (BPS) is a well known problem and a major cost for the Irish beef industry. It is caused by cold-loving Clostridia, specifically *Clostridium estertheticum*, *Clostridium gasigenes* and other species, and occurs in correctly chilled batches (0-2°C) after two to four weeks. As spoilage is characterised by the production of large volumes of gas, a putrid smell (H₂S) and a metallic sheen on the

meat, meat spoiled in this way has no commercial value. Much work has taken place at Teagasc to further understand the causes of spoilage and to assist in control and detection.

Research

Recent research at Teagasc Ashtown Food Research Centre (AFRC) discovered a new Clostridial species capable of causing BPS. This new species is more common in Irish abattoirs and spoils meat relatively quickly. Genetic analysis of this strain revealed a target gene sequence forming part of the gene encoding the 16S ribosomal RNA, which can be used to specifically detect the presence of this bacteria to the exclusion of all other Clostridial species and other spoilage bacteria. An RT-PCR assay was developed, and validated using primers and probes designed using this sequence, and the resulting assay was patented.

Nature of service

As this assay is specific to the novel strain discovered and shown to be the primary cause of BPS in Irish abattoirs, it offers the advantages in terms of precision and time associated with real-time PCR, but also, as the detection of all three causes of spoilage is now possible, it makes this test more useful than previous methods.

Benefit to industry

Testing of meat samples using this unique service will allow meat companies to assure product quality, validate in-plant decontamination activities and investigate the cause/source when a BPS incidence occurs. Results are available in two working days.

Further information

For further information or to use this service, which has already generated a considerable client base, please contact Joan Carroll, Tel: 01 805 9534/805 9500, or E-mail: joan.carroll@teagasc.ie, or Dr Declan Bolton, E-mail: declan.bolton@teagasc.ie, at AFRC.

Anti-parasitic drug testing service

Background



Anti-parasitic agents are important for the control and treatment of infections in food-producing animals. These products are safe if withdrawal periods and product labels are adhered to. However, undesirable levels of residues may be detected in food if good practice is not followed, leading to requirement for regular monitoring. Until recently, anti-parasitic agents have been monitored inefficiently using chromatographic and

immunochemical assays. Researchers at Teagasc Ashtown Food Research Centre (AFRC) observed the need for more sensitive and efficient techniques for the monitoring of anti-parasitic agents and incorporated this into the AFRC residue research and development programme.

Research

In 2007, the development of state-of-the-art technology for the detection of anti-parasitic agents in collaboration between Teagasc and the United States Department of Agriculture began in earnest. The objective was to develop a detection method capable of detecting all of the major anti-parasitic agents in food. Over the past two years this technology has been developed and fine-tuned at AFRC. The validated method allows the detection of residues to current limits set in the EU. This method is currently the most sensitive, and the only method that tests this wide range of compounds. The limit of detection of the method is compound-specific, ranging between 0.1ppb and 2.5ppb, depending on the residue.

Nature of service

In 2009, this method was accredited by the Irish National Accreditation Board. The residue studies group based in the Food Safety Department at AFRC now offers this as a service to the food industry. Residue results for test samples (meat and dairy products) can be rapidly obtained if necessary.

Benefit to industry

This technology will allow industry to ensure compliance with current EU legislation, thereby confirming the purity and safety of their product. The technology has been comprehensively evaluated through participation in independently organised inter-laboratory proficiency tests.

Further information

For further information or to use this service, please contact Dr Mary Moloney, Tel: 01 805 9919/805 9500, or E-mail: mary.moloney@teagasc.ie, or Dr Helen Cantwell, E-mail: helen.cantwell@teagasc.ie, at AFRC.

T Science Week 2009



Bringing science alive at Teagasc

Teagasc held a range of exciting events around the country as part of its Science Week activities.

Teagasc, in supporting Discover Science and Engineering's goal of "promoting the relevance of science, engineering and technology, and to demonstrate

their importance to the future development of Irish society and the economy", organised a number of exciting events for second- and third-level students at Ashtown, Athenry, Grange, Moorepark and Oak Park. Researchers Nigel Brunton and Douglas Sorensen from Ashtown also gave a talk on functional foods at Blanchardstown Public Library.

The theme of this year's Walsh Fellowships annual seminar at the Royal Dublin Society was 'Innovation in the agri-food sector', reflecting Teagasc's mission of supporting science-based innovation in the agri-food sector, with guest speaker Ms Damini Kumar from NUI Maynooth, European Ambassador for Innovation and Creativity. Ms Kumar encouraged the young scientists who are finishing their PhD programmes to be innovative. She said: "Publication in scientific literature is an essential part of the process, but in today's economic climate,





you must have an eye on the application of your work within the sector. Innovation will be central to your future careers both inside and outside research". She emphasised the role of creativity and innovation in realising a smart green economy in Ireland. She also said that we need to invest in stronger collaboration, partnership and linkages between universities, research centres, the public sector and businesses, and to create synergies in their activities: "We need to build on Europe's diverse knowledge infrastructure and encourage networking". Dr Gerry Boyle, speaking at the seminar, said: "I am particularly pleased that the focus of this year's Walsh Fellowships Seminar is on the contribution of Walsh Fellowships to innovation in the agri-food sector. As a mission-driven organisation, Teagasc is wholly committed to ensuring that the State's investment in R&D results in a pay-off in terms of new information and

technology that will enable our farmers, food companies and bio-industries be more innovative and successful on national and global markets. It is important that our Walsh Fellows identify with this mission and that their training in Teagasc is innovation-focused.

"PhD students today must be prepared for a variety of careers outside of academia and they must above all be to the forefront in helping build Ireland's international reputation in agri-food and in green technology and sustainable development".

Articles describing the research carried out by the winners of the best presentation and best poster at the seminar are featured in the following pages. Well done to the Science Week Committee and all the staff involved, who ensured the successful running of all Teagasc's Science Week events.



CLOCKWISE FROM TOP LEFT: BSc students from Carlow Institute of Technology visit Oak Park Crops Research Centre. Oak Park researchers Drs Joanne Fitzgerald, Dan Milbourne (front) and Denis Griffin (far left), with Dr Thomaé Kakouli-Duarte (middle left), Carlow IT, are pictured.

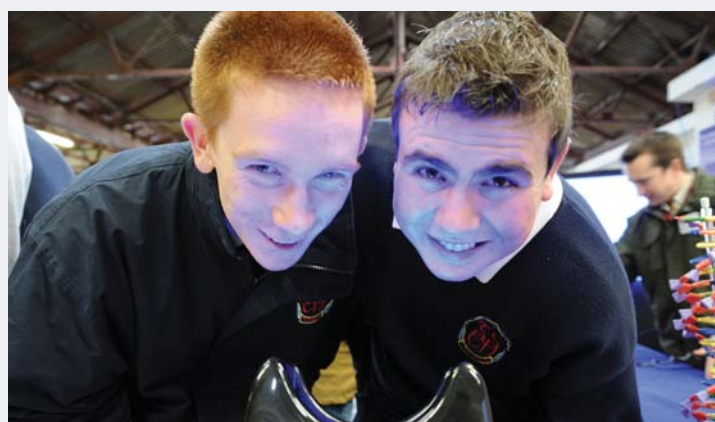
Ms Damini Kumar from NUI Maynooth, European Ambassador for Innovation and Creativity, was guest speaker at the Teagasc Annual Walsh Fellowships seminar as part of Teagasc's Science Week events.

Pupils from St Dominic's School, Cabra, are asked 'How clean are your hands?' at Teagasc Ashtown Food Research Centre's Science Week open day.

Grass researcher Alistair Black with students Stacy Duignan and Hazel Coleman from Scoil Mhuire, Trim, at Teagasc Animal Production and Grassland Research Centre, Grange's Science Week open day.

Enjoying the Athenry Science Week open day are Patrick Hynes and Liam Hanlon from New Inn Secondary School, pictured visualising DNA using UV light.

Dr Debebe Alemayehe, Teagasc, Moorepark, addressing a group of students from St Colman's College, Fermoy, about the opportunities for a science-based career in agriculture and food research.



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T Science Week 2009



Biocontrol of *E. coli* O157:H7

BRID COFFEY won the best presentation award at the annual Walsh Fellowships seminar for her project, which is looking into the use of phage as a biocontrol for *E. coli* in cattle.

Escherichia coli O157:H7 is a verotoxin-producing *E. coli* (or VTEC) and can cause serious illness in humans, ranging from bloody diarrhoea to kidney failure, and even death. Those most at risk are the young, the elderly, pregnant women and those with an already weakened immune system. Livestock are the reservoir for most VTEC, with cattle being the principal source of *E. coli* O157:H7. The primary cause of human infection by VTEC is via consumption of contaminated meat products. Studies have demonstrated that the presence of VTEC on the hide and carcass of an animal prior to slaughter has led to both direct and indirect contamination of raw and processed meats. Other important risk factors include consumption of fresh produce such as lettuce and spinach, drinking untreated water from private wells and contact with infected animals or contaminated environments.

Our research, in collaboration with Dr Geraldine Duffy's group at Ashtown Food Research Centre (AFRC), has centred on the investigation of specific biocontrol methods for VTEC, and the assessment of whether these agents can be applied to reduce numbers of *E. coli* O157:H7 at key points in the beef chain. The therapeutic use of bacteriophage (virus that attacks bacteria) to treat pathogenic bacterial infections is a viable option for the control of this pathogen. Specific phage isolated against VTEC have the potential to be used to reduce numbers of the pathogen – either as animal feed inoculants or as decontaminants in foods. In this study we isolated two lytic phage against *E. coli* O157 from bovine farmyard slurry samples. Phage e11/2 and e4/1c specifically inhibit *E. coli* O157 but have no impact on humans or animals.

The complete genome sequences of e11/2 and e4/1c have now been determined by our group. Phage e11/2 is very similar at the genome level to a previously isolated and well-studied phage called T4. However, while T4 infects non-pathogenic *E. coli*, e11/2 is specific for strains of VTEC due to the presence of a very specific tail fibre protein. A manuscript is currently in press in which a detailed genome comparison of both phage is reported. Phage e4/1c is also specific for VTEC, with similarities reported between this phage and two documented *E. coli* bacteriophage – RTP and JK06. Importantly, neither phage harbours any toxin genes, which would prohibit its use as a phage therapy agent. To determine if these phage would act as efficient biocontrol agents *in vivo*, initial investigations in a model rumen system were performed. An *E. coli* O157:H7 strain was added into rumen fluid taken from fistulated animals. Phage e11/2 and e4/1c were then added and *E. coli* O157:H7 numbers measured over a 24-hour period. With phage e11/2, a significant reduction in *E. coli* O157:H7 numbers was measured, with pathogen numbers dropping below the level of detection within one hour. Results for phage e4/1c also demonstrated a reduction of pathogen numbers.

Phage e11/2 and e4/1c did not affect rumen fermentation indicating the advantages for using these phage for subsequent animal trials.

Work is ongoing at AFRC to determine the ability of our phage to reduce numbers of *E. coli* O157:H7 in the gastrointestinal tract of cattle. Results from

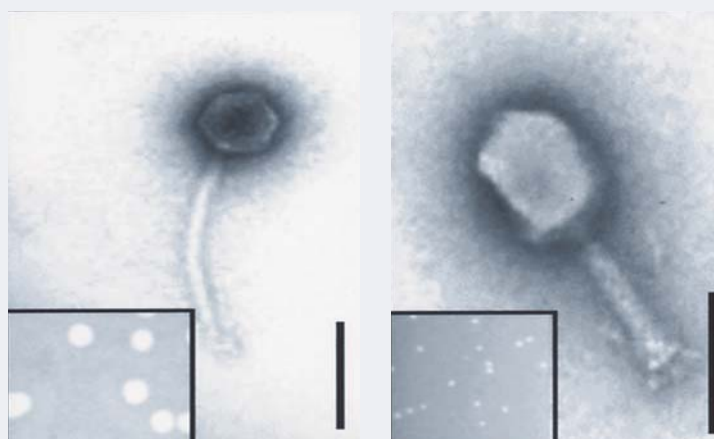


Image 1.

Image 2.

Electron micrographs of bacteriophage: Image 1 = e4/1c bacteriophage and Image 2 = e11/2 bacteriophage. The image in the left corner represents phage plaque size on a lawn of *E. coli*. The bar size represents a scale of 100nm.

one such trial demonstrated dramatic reduction in *E. coli* O157:H7 numbers on administration of deliberately inoculated O157 to the animals. This finding suggests a difficulty with colonisation of the pathogen within the lower recto-anal junction of the animal. However, it was observed that both e11/2 and e4/1c were recoverable from the faeces, implying survival through the gastrointestinal tract, a critical advantage to use of these agents *in vivo*. The results to date from this study are promising and indicate that phage e11/2 and e4/1c have great potential in the control and reduction of *E. coli* O157:H7 at key stages of the beef chain.

This research was funded by the Food Institutional Research Measure (FIRM) of the Department of Agriculture, Fisheries and Food, and is in collaboration with MFRC and AFRC.

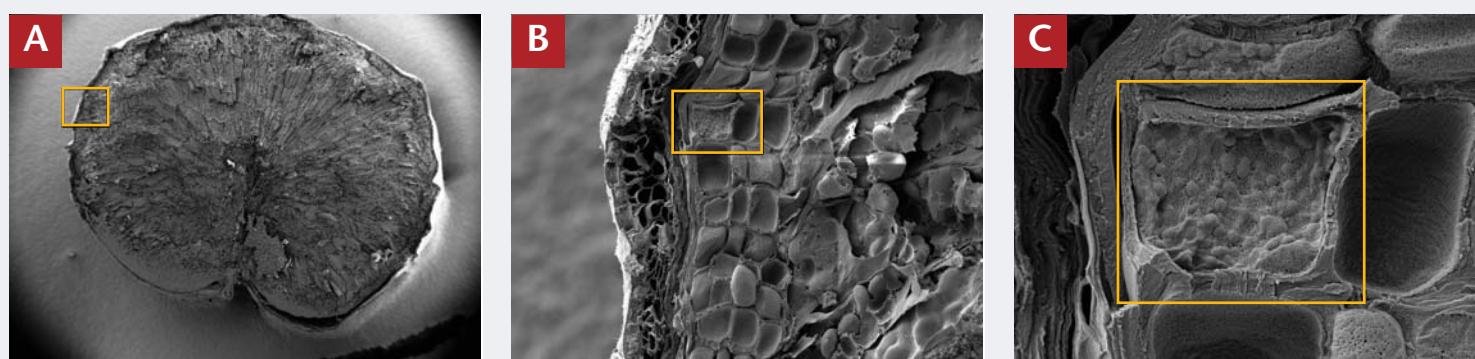


Brid Coffey is a Teagasc Walsh fellow at Teagasc Moorepark Food Research Centre (MFRC). Her supervisors are Professor Paul Ross, Head of Food Research, Teagasc; Dr Olivia McAuliffe, Senior Research Officer, MFRC; and, Dr Aidan Coffey, Senior Lecturer at Cork Institute of Technology.



Better bread using barley

'Enhancing the nutritive aspects of wheat bread through the inclusion of milled barley fractions' was the title of the poster that won PAUL SULLIVAN the best poster award at the annual Walsh Fellowships seminar.



Scanning electron micrographs of wholegrain barley grain at increasing magnifications. (A): magnification 63x. (B): magnification 1,230x. (C): magnification 5,000x.

Barley has long been known as a good source of fibre, in particular the soluble fibre 'beta-glucan', but this is only now being exploited by the food industry. In 1997 the US Food and Drug Administration (FDA) approved a health claim for the use of oat-based foods for lowering the risk of heart disease and passed a unique ruling that allowed oat bran to be registered as the first cholesterol-reducing food at a dosage of 3g beta-glucan per day, with a recommendation of 0.75g of beta-glucan per serving. More recently, similar health claims regarding the beta-glucan found in barley have also been approved.

In this project, barley grain (300kg) was milled at Ashtown Food Research Centre to produce three different milled fractions: flour, bran and middlings. These fractions were analysed for protein, fibre, starch and amino acid content to assess whether the fractions had potential for use as a functional ingredient or not. From the results it was evident that the middlings fraction – a fraction usually discarded after the milling process – had a high nutritive value, showing particularly high levels of soluble fibre and high levels of beta-glucan.

A trial was then undertaken to investigate how the substitution of barley middlings into a bread formulation would affect the texture, shelf life and sensory properties of the final baked bread product.

After a number of preliminary trials, it was found that barley middlings could be added to a bread formulation as a 60% substitute for wheat flour and still produce a viable dough, and five different substitution levels were subsequently assessed:

1. 100% wheat flour (control)
2. 85% wheat flour, 15% barley middlings
3. 70% wheat flour, 30% barley middlings
4. 55% wheat flour, 45% barley middlings
5. 40% wheat flour, 60% barley middlings

Fundamental and extensional dough rheology, texture analysis, sensory analysis and a number of compositional tests (fibre, beta-glucan, protein and amino acid analyses) were carried out on the flour blends, doughs and breads of each

formulation in order to assess their viability. From these results it was apparent that the inclusion of barley middlings above a 30% level produced firmer doughs and breads that had undesirable baking properties (low loaf volume, firm crumb texture). Gluten plays an extremely important role in the development of a bread's ultrastructure. Wheat flour is rich in gluten, whereas barley has very low levels of gluten; therefore, it is most likely that this may have had a detrimental effect on the final product.

However, at a 30% barley middlings inclusion, the breads were found not to differ significantly from the wheat bread control. Also, the 30% inclusion of barley middlings increased the beta-glucan content of the bread five-fold, and more than doubled the fibre content. If this bread were to be commercialised, two slices from a standard 800g loaf would contain approximately 0.8g of beta-glucan – this is above the 0.75g per serving required for a product to make a health claim for lowering the risk of heart disease.

Additional research is now being carried out to further improve the overall structure and quality of the 30% barley middlings bread through the use of enzymes and also by analysing different cultivars of barley to assess if barley cultivars with high beta-glucan yields can be included into the formulation at a lower substitution level and still produce the desired health-promoting effects.

Acknowledgement

This research was funded by the Teagasc Walsh Fellowship Scheme under the Food Institutional Research Measure (FIRM) of the Department of Agriculture, Fisheries and Food.



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A new era for European research and innovation

Leveraging research and innovation to help the EU emerge from the current financial crisis was one of the central themes of Máire Geoghegan-Quinn's address to MEPs recently, as she outlined the priorities for her term as European Commissioner for Research, Innovation and Science.

Máire Geoghegan-Quinn, a former government minister and member of the European Court of Auditors, was sworn in as European Commissioner for Research, Innovation and Science on February 10. As part of the approval process for this post she faced the Industry, Research and Energy Committee of the European Parliament, where she described her vision for European research and innovation.

The European Commission operates in a similar manner to our Government Cabinet, with Commissioners having a similar role to our ministers. The new Commission numbers 27, including the President, a High Representative of the Union for Foreign Affairs and Security Policy and 25 other Commissioners. While there is one Commissioner per member state, they are bound to represent the interests of the EU as a whole rather than their home state. Each new Commissioner needs the approval of the people of Europe, as represented by the Parliament, before they can take up their roles. As part of this process, Commission candidates must face three-hour public hearings where they take questions from parliamentary committees dealing with the policy areas in their future portfolios. MEPs evaluate candidates' knowledge and competence, commitment to the EU, personal independence and political priorities.

Vision for the future

Setting out a vision for her new role, Geoghegan-Quinn said: "The EU must become a true innovation union ... my task will be to put research, innovation and science at the heart of EU policies". Looking to the future, she added: "In a new economy, refined knowledge will replace crude oil as the economy's prime motive force". However, she went on to emphasise that knowledge for its own sake is not sufficient, stating: "If we want to take Europe out of the economic crisis in which it is at the moment, then we have to innovate ... taking the research and transferring it into jobs", a point that is strongly reflected in the European Economic Recovery Plan. Completing the European Research Area (ERA), addressing major challenges such as climate change, energy efficiency and ageing, and creating an innovation research culture were the three priorities Geoghegan-Quinn proposed for her term of office.

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European Research Area

The concept of an ERA was adopted by the EU in 2000. It encompasses three inter-related aspects: a European 'internal market' for research, where researchers, technology and knowledge can freely circulate; effective European-level co-ordination of national and regional research activities, programmes and policies; and, initiatives implemented and funded at European level. The resulting reduction in fragmentation and duplication should give better value for each Euro spent on research in the Union. This is necessary if the EU is to compete with the USA and Japan, as well as newly emerging scientific and technological powers such as China and India.

In her opening address, Geoghegan-Quinn highlighted five key areas that require focus in order to make the ERA a reality. These include: ensuring that researchers' working conditions, pension rights and entitlements will be protected as they move between member states; a commitment to co-ordinate national research programmes in areas of major challenges; a framework to facilitate pan-European research infrastructures; management of intellectual property; and, international co-operation. She emphasised the need for a better investment climate for research, and the importance of encouraging frontier research through an independent European Research Council.

Major research challenges

On the grand challenges facing Europe and the world, Geoghegan-Quinn said that climate change research had changed hearts and minds throughout the world. The next step is to see how climate change will impact on the lives of citizens. On the issue of energy, she said that the EU's Strategic Energy Technology (SET) Plan will be implemented as a priority. The SET-Plan sets out a vision of Europe as a world leader in a diverse portfolio of clean, efficient and low-carbon energy technologies, with these serving as a motor for prosperity and a key contributor to growth and jobs.

In the context of an ageing EU population, the Commissioner described the research on healthy ageing, and new medical approaches to transform citizen's lives, as "critical challenges" for Europe.

CAREER PROFILE

When first elected to Dáil Éireann in 1975, Máire Geoghegan-Quinn was one of only four female TDs among a total of 144. She went on to become the first woman to hold a cabinet post since the foundation of the State, when she was promoted to Minister for the Gaeltacht in 1979. Her 22-year political career saw her occupy various ministries including Education, European Affairs (where she co-ordinated the organisation of the Irish Presidency of the European Union in 1990), and finally, Justice. Her time in the Department of Justice was characterised by a number of significant successes and reforms, including the negotiation of the Downing Street Declaration, which later paved the way for the Good Friday Agreement. In 2000, she was appointed to the European Court of Auditors, an appointment that was renewed for a second term in 2006. In 2010, she became Ireland's first female European Commissioner when she was appointed Commissioner for Research, Innovation and Science.

LEFT: Hearing of Máire Geoghegan-Quinn, Irish Member-designate of the European Commission in charge of Research, Innovation and Science, before the European Parliament Industry, Research and Energy Committee, and with the participation of the European Parliament Education and Culture Committee.

Innovation research culture

The move to an innovation research culture was a key theme of Geoghegan-Quinn's address. She cited a disconnect between science and society: "Ultimately, communication of the benefits of research to EU citizens is a priority to garner the public's support for the research agenda and this aspect must be achieved if we are to be an innovative society". Another key step on this road is increasing the number of women scientists. As a trailblazer for women in politics (see panel), Geoghegan-Quinn is well placed to address the barriers that may hinder women's participation in science.

Framework Programme 7

As Commissioner for Research, Innovation and Science, Geoghegan-Quinn will take charge of the €50 billion research programme known as Framework Programme 7 (FP7). This is the largest public research programme in the world, and its previous incarnations (FP1 to FP6) have been instrumental in fostering the development of the ERA. Ireland has had great success in attracting funds from this programme, receiving €152 million since it started in 2007, with an overall success rate of 23.51%, above the European Member State average of 21.68%. In the area of food, agriculture, fisheries and biotechnology, Ireland has been particularly successful, attracting over €8.5 million of EU funding. Teagasc has participated in 16 FP7 projects so far. In total, these projects are worth almost €3.5 million to Teagasc but, more importantly, as they are collaborative projects with European partners, they allow us to tap into knowledge generated from €54 million worth of research.

However, the Commissioner emphasised that FP7 must be an instrument and not an end in itself. Returning to one of her central themes, she said that the involvement of small and medium enterprises (SMEs) is vital, and that in order to encourage this the Commission would introduce more innovation-friendly rules. The former member of the European Court of Auditors said that she would aim to "maximise simplicity without compromising on audit or evaluation quality". This balance was neatly encapsulated in her observation that "a world of zero risk is a world of zero innovation".

In concluding, the Commissioner stated that the EU has "entered the age of innovation where we can be followers or leaders. We are at our best when working in the future tense".

National reaction

National reaction to the appointment has been very positive. Brendan Smith, Minister for Agriculture, Fisheries and Food, welcomed the Commissioner's appointment and the EU priority of delivering results to the market. "Commissioner Geoghegan-Quinn did an excellent job in presenting the research priorities to the Parliament. It is critical that we place research and innovation at the centre of EU policy and that we see the results of research making a difference in the lives of Europeans in terms of innovative technologies, as well as the obvious economic impacts of job creation and economic stimulation. This is something we are particularly good at in agriculture, fisheries and food research. Working with our EU partners adds critical mass in delivering solutions to the world's problems."

***The EU has entered the age of innovation
where we can be followers or leaders.
We are at our best when working
in the future tense.***

Commenting on the announcement, Professor Gerry Boyle, Director of Teagasc said: "The appointment of an Irish Commissioner for Research, Innovation and Science, and especially someone of the calibre of Mrs Geoghegan-Quinn, is particularly welcome for the agri-food sector, and the wider bio-sector at the present time. Science-based innovation support, which is Teagasc's mission, is key to securing the competitiveness of our agri-food sector and thus underpinning profitability and job creation". Professor Boyle said he hoped that Mrs Geoghegan-Quinn would be able to visit some of Teagasc's world-class research facilities in the near future and learn at first hand how Teagasc has developed a justifiable international reputation for turning science into value for the benefit of the Irish agriculture and food industry.

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Teagasc's national landcover and habitat maps

Teagasc researchers have used sophisticated computer and satellite technology to produce a digital indicative soil map of Ireland.

In 1998 the 'Irish Forest Soils' project was established by Micheal Bulfin, Forestry Research, Kinsealy. Funded by the Forest Service of the Department of Agriculture, Fisheries and Food (DAFF). Its remit was to map, using modern computer and satellite observation methods, the 56% of the country that had not been mapped by the Teagasc Soil Survey, which closed in the early 1980s. Subsequently, the project was extended to cover the entire country, and this was funded by the Department of the Environment, Heritage and Local Government (DEHLG), managed through the Environmental Protection Agency (EPA), and known as the 'Teagasc/EPA Soils and Subsoils Project'.

To recreate the extensive field mapping approach that was used in the soil survey and that resulted in the well-known county soil maps and bulletins would have required a large input of resources. New technologies enabled us to map those elements that we could see by satellite and aircraft, and in conjunction with other information we created a soil map through inference using a pedological-rule-based approach. The soil model and its outputs are to be detailed in the next issue of *TResearch*. In this article we will examine two of the inputs created within the project: the national landcover and habitat maps.

Landcover maps

Early on in the project it was decided that in order to help predict what type of soils were present we would need to create a landcover map, as the type of landcover present is often dictated by the soils. A good example is the presence of rushes, i.e., a 'wet grassland', indicating a poorly drained soil. There was at the time a national landuse map, CORINE 1990. However, the spatial resolution was too crude, it mapped only areas greater than 25 hectares and we needed to map to one hectare. Therefore, we created a national landcover map using a hybrid supervised classification of satellite imagery.

Earth observation by satellite

At the start of the project we had the largest suite of contemporary geospatial datasets available, including ordnance survey mapping, a national 3D aerial photography coverage and full image coverage, from 1995, of the country taken by a multispectral space instrument, the Thematic Mapper (TM) carried onboard the American satellite LANDSAT 5.

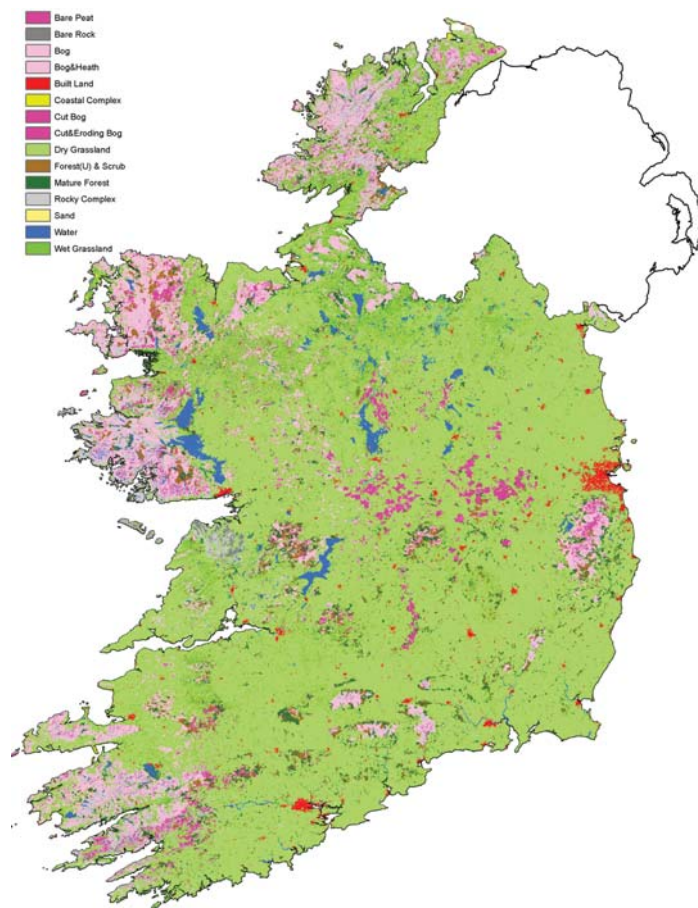


FIGURE 1: The National Teagasc Land Cover Map 1995 (TLC95).

A multispectral instrument takes images much like a conventional digital camera but, as well as recording blue, green and red channels, to make up the natural colour image we are familiar with, it also records in four other channels, notably the very near infra red (VNIR – good for detecting biomass), the near infra red (good for discriminating water and soils) and the thermal infra red, creating what are known as 'false colour' images.

These images are made up of pixels that contain a value for each of the seven channels; these values allow you to distinguish between surfaces imaged by the satellite. As you might with a normal digital picture, you could label all the green pixels grass and the blue pixels water, but the multispectral nature of the image allows you to fine-tune your classification (in normal colour mode different crops look the same but using the VNIR information we can distinguish crop types). There are millions of pixels in each image (and 12 images in all were used to map Ireland), so automatic methods have been created to speed up the process of classification.

Supervised classification

Supervised classification is the process of using samples of known identity (pixels assigned to known landcover types) to assign unknown pixels from a satellite image to the correct class of landcover. The analyst defines 'training areas' by identifying regions on the image that can be clearly matched to areas of known identity. Such areas typify spectral properties of the categories they represent and are relatively

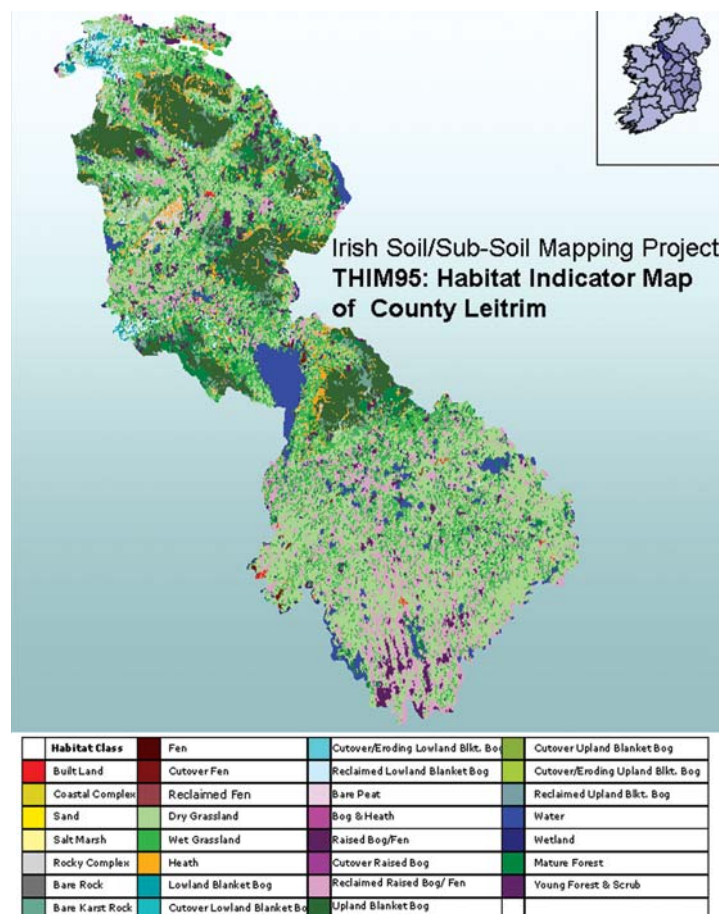


FIGURE 2: Extract from the National Teagasc Habitat Indicator Map (THIM95): County Leitrim as presented in the Final Report (Vol. II).

homogeneous. Our classification process was further refined within a rule-based system using other data sets. For instance, a pixel could only be classified as 'bog' if it occurred in the image over an area mapped as peat in our sub-soil map. Thus, one of the core tasks in landcover classification of imagery is the collection of training areas (also known as ground truth). In this project, training data were collected using softcopy photogrammetry, which allows the user to see high-resolution aerial photography in 3D. The database used was the national airborne monochrome aerial photography survey of 1995. It is a well-established principle that remote sensed data of high spatial resolution (aerial photography) can be used to ground truth data of a lower spatial resolution (satellite images). Softcopy photogrammetry uses a digital version of the airphoto image as input for a series of mathematical models that reconstruct the orientation of each image pair. This process requires specialised computer software and hardware, which analyses the data, presenting the operator with a 3D aerial view of the landscape. Our then colleague, Monty Loftus, virtually 'flew' over the country using this system, visiting points on a 2km grid and collecting the actual landcover as observed in the photography for 15,000 points. These were used to train the system that created the National Teagasc Landcover Map 1995 (TLC95). It is important to note that because the map was produced for a soil project, and the soils do not change over a short time, it was not important that the map be up to date, only that it should be consistent with our other data sets.

After many iterations, the maps were produced on a county by county base and tested against field work (>3,000 field observations in total and more points collected via photogrammetry) so each map attained our stated accuracy of 85%.

Habitat map of Ireland

The aim of the habitat indicator mapping element of the project was to indicate the likely distribution of habitats throughout Ireland. The map is an enhancement of the landcover map achieved by increasing the classification and spatial resolution of many of the landcover thematic classes, namely 'Bog & Heath', 'Cut Bog', 'Cut & Eroding Bog', 'Wet Grassland' and 'Dry Grassland', using a more refined version of the rule-based approach. These landcover classes are indicative of habitat type in that they represent combinations of more detailed habitat classes.

The map is produced using these land cover classes in combination with other thematic maps, namely 'Subsoil', 'Digital Elevation Model (DEM) derivatives', and an extract line from the Ireland Peatland Map. The focus of the habitat indicator mapping exercise is to exploit the known associations of landcover, subsoil, elevation and location with habitat in Ireland.

The rule base is a series of conditions that dictate the mapping of particular habitat indicator classes. For example, in indicating the likely presence of 'lowland blanket bog' as a thematic class, the expert rule base demands the following conditions: 'Bog & Heath' as a class from the landcover map; 'Peat' from the Subsoil map; elevation less than 150m from the DEM (a DEM is a 3D computer model of the landscape surface); and, location west of a line defined in the Peatland Map to mark the eastern limit of lowland blanket bog.

There are over 160 conditions defined to model the habitat indicator map. Fourteen new habitat indicator classes are modelled from five of the landcover classes. For example, 'Bog & Heath' from the TLC map in peat settings is reclassified to 'Upland Blanket Bog', 'Lowland Blanket Bog' and 'Raised Bog/Fen'. In non-peat settings it is subdivided and reclassified to 'Heath'.

Benefits to industry and further work

Teagasc has produced the first and only national landcover and habitat maps at this resolution. They are freely available to researchers and are especially useful for geographical information systems (GIS) applications and fieldwork planning. The use of satellite imagery is a good example of the use of earth observation technology in Ireland. A new project starts in 2010 to produce an up-to-date version of the landcover map and to further bring earth observation technology into farm management and productivity improvements in grassland.

Acknowledgements

The authors would like to acknowledge Dr Monty Loftus, project botanist and co-creator of the TLC and THIM maps, who is now working with Fingal County Council. Funding was provided under the National Development Plan by the Forest Service (DAFF) and DEHLG.



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The trend in agricultural employment indicates that not only are the absolute numbers working in the industry falling, so too is the sector's relative share of total employment.

Impact of the economic downturn on part-time farmers

Part-time farmers have been particularly vulnerable to the effects of the economic downturn. This is one of the findings of an analysis of employment in the sector undertaken by DAVID MEREDITH, Teagasc Rural Economy Research Centre.

This research was undertaken by Teagasc following a request from the National Rural Network (NRN) for information on the impact of the current economic downturn on off-farm employment patterns. It considers changing employment trends in the agriculture, forestry and fishing sectors and evaluates the impact of the economic downturn on part-time farmers.

Employment change in the agriculture sector 2004 to 2009

The total number employed in agriculture, including all persons working on livestock, tillage and horticulture farms, engaged in hunting and related services and employed in forestry, logging and related activities, initially declined from roughly 114,000 to 110,000 between 2004 and 2005, and thereafter remained at this level until the third quarter (Q3) of 2007. These figures also contain a small number, approximately 2,000, that work in the fishing and fish farming sectors. From late 2007 to the end of 2008 agricultural employment increased to 115,000 before witnessing a rapid decline during 2009 to a low of 98,000. These trends track developments in the wider economy, with declining agricultural employment (2004-2007) corresponding to increasing off-farm employment opportunities. With the fall in non-agricultural employment opportunities from 2007 onwards it is possible that those working off-farm re-engaged in agriculture on a full-time basis, thereby accounting for some of the increase in the total number employed in the sector. A secondary factor that may have contributed to the increase in employment during this period was the significant

growth in commodity prices. In the first six months of 2009 the numbers employed in agriculture fell by 15.43%. This fall brings the total number of people employed in agriculture, expressed as a proportion of the total workforce, to 5.03%, the lowest level recorded during the 2004-2009 period. The trend in agricultural employment indicates that not only are the absolute numbers working in the industry falling, so too is the sector's relative share of total employment, as other industries continue to hold employment, and in a number of instances grow, despite the economic downturn.

An evaluation of the structure of employment in the agriculture sector highlights that the primary driver of the change between Q2 2008 and Q2 2009 is a fall in the number of self-employed workers followed by a decline in the number of employees. During the 12 months in question, the total number of people employed in the agriculture sector fell by 17,600. The reduction in the number of self-employed individuals, from 87,100 to 74,900, accounts for 69.3% of the total fall in the agricultural workforce. A further 30.1% of the decline is accounted for by the reduction in the number of employees (-5,300 persons). Finally, there was a small drop (-100) in the number of persons 'assisting relatives'. These results represent a significant development. Whereas in the past agriculture was viewed as an industry with the means of providing employment opportunities to unemployed males in rural areas, it is apparent that this is not currently the case, as evidenced by the decline in both the number of employees and those assisting relatives working in the agriculture sector.

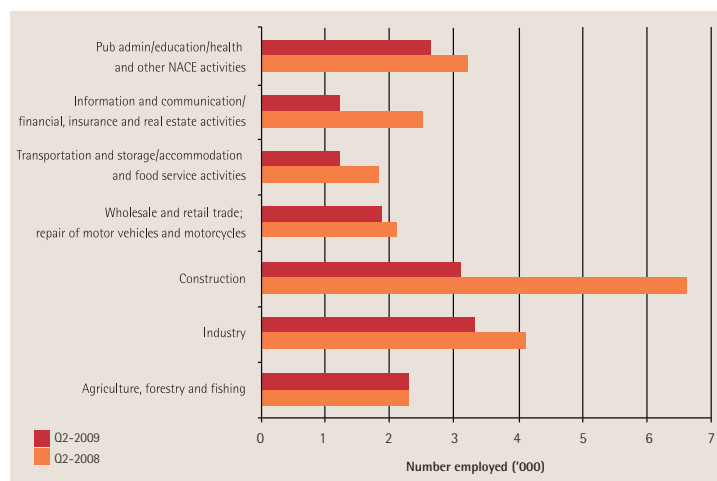


FIGURE 1: Changes in the number of farmers with off-farm jobs Q2 2008 to Q2 2009.

Economic change 2008 to 2009: impact on off-farm employment

The data presented thus far highlight the decline in agricultural employment. They do not, however, provide any indication of the impact of the economic downturn on farmers that engage in off-farm employment. The most recent data from the Teagasc National Farm Survey (NFS), relating to 2008, indicate that 40% of all farmers held an off-farm job (Connolly *et al.*, 2009). For these individuals, off-farm income accounted for 71% of their total household income, highlighting the vital importance of off-farm employment to farm households and in contributing to the viability of the farm enterprise.

Data made available by the CSO from the Quarterly National Household Survey (QNHS) enables an assessment of the impact of recent developments on off-farm employment. The QNHS records an individual's primary and, where they have another source of employment, secondary occupation. Analysis of the total number of persons with a secondary job in agriculture, meaning that they are part-time farming, in Q2 2008 and Q2 2009, highlights a fall of 6,900 or 30.5%, from 22,600 to 15,700. This development resulted in a reduction in the proportion of all farmers with off-farm income from 19.8% to 16.1%.

Of the 22,600 persons with a secondary job in agriculture and a primary job off-farm, 57.5% were employed in agriculture, forestry or fishing, industry or construction as of Q2 2008 (Figure 1). A detailed assessment of changes in the sectoral composition of off-farm employment highlights the variance in the numbers losing their jobs depending on which sector they worked in.

Unsurprisingly, those working in construction, the most important off-farm employment sector, witnessed the greatest fall in employment (Figure 1). By Q2 2009 the proportion of farmers with an off-farm job in construction had fallen from 29.2% to 19.75% in the space of 12 months and accounted for 50.7% of the total reduction in off-farm employment recorded by the QNHS during this period.

Placing the declines in off-farm employment within the national context of increasing unemployment, one finds that those with a secondary job in agriculture, in general, face a greater risk of unemployment. Nationally, the number of persons employed declined from 2,117,000 to 1,944,900, a reduction of 8.1%. For those with a secondary job in agriculture, the reduction was 30.5%. By way of example, within the national workforce, for every 1,000 persons

employed in the construction sector in Q2 2008, 350 had lost their jobs one year later. The equivalent figure among part-time farmers was 530. Two key factors are thought to influence the level of exposure to unemployment: education and skill levels; and, geographic location relative to employment opportunities. Research undertaken by Behan and O'Brien (2007) established that educational qualifications among farmers are, in general, low, with 70% of all farmers recording lower-secondary education as their highest qualification. As of 2006, only 6% of farmers had a third-level degree (Behan and O'Brien, 2007). Dillon *et al.* (2009) found that those within the workforce with low education and skill levels are more likely to become unemployed and spend longer periods being unemployed.

Implications for industry and future research

The analyses presented in this article point to significant and rapid economic change in Ireland and the impacts of these developments on part-time farmers. While the declines in off-farm employment recorded in the QNHS are unsurprising given the rapid deterioration of the Irish economy over the course of the period Q2 2008 to Q2 2009, they are of significant concern given the extent to which off-farm income supports the viability of many farms. Given the likely difficulty for many farmers who depended on off-farm employment to secure new employment, there is a clear need for a strategy to develop the rural economy, thereby creating employment opportunities, through diversification of traditional rural industries. Parallel to this process is the need to further develop the existing (formal and informal) skills of farmers to enable them to participate in the development of the rural economy.

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Consumer insights: bridging the value gap

DOUGLAS SORENSON and MAEVE HENCHION discuss the role of understanding what consumers value in consumer-led new product design and its importance in improving the market competitiveness of value-added foods.

Strategic reviews of the Irish food industry have consistently emphasised the need for companies to invest in their technological and marketing capabilities to manage risk in new product development (NPD) and increase value-added levels. Indeed, for some companies there can be an expectation that adopting new technologies to create radically innovative new products will automatically create value and lead to a distinct competitive advantage in the marketplace. However, companies often fail to recognise that technological advances that seek to add value do not necessarily give rise to consumer value. Thus, product design strategies that seek to add 'superior value' to foods should be assessed from the consumer's perspective.

Multi-disciplinary NPD research

The development of minimally processed foods presents challenges to companies in terms of optimising product formulations without compromising on shelf life and sensory quality. In that context, high pressure processing (HPP) may represent a novel and commercially attractive alternative to existing process technologies. HPP is a non-thermal processing technology that involves the application of hydrostatic pressure to inactivate microbes and extend the shelf life of foods, and/or to preserve the nutritional and sensory quality of foods and beverages. Current commercial applications of HPP include the development of value-added juices, condiments and cured cooked meats. For consumers, products produced using HPP have the potential to deliver high levels of added value, as well as margins for manufacturers and retailers. For traditionally short to medium shelf life products such as chilled ready meals, HPP could also assist companies to exploit export market opportunities. However, the development of HPP chilled ready meals presents considerable challenges from a technological perspective given the low acidic nature of chilled ready meals, as well as difficulties in identifying the optimal processing

parameters for a multi-component product. Similarly, from a marketing perspective, while radically innovative products or processes such as HPP can be potentially rewarding, they are also a risky form of NPD activity. That is, while a higher level of innovativeness may be associated with a higher degree of competitive advantage, it also runs the risk of reduced consumer acceptance. The Food Marketing Research Unit and the Meat Technology Department based at Teagasc Ashtown Food Research Centre (AFRC), in collaboration with UCC, are close to completing a three-year project, which aims to develop consumer-led chilled ready meals produced through the application of HPP. The consumer research strand of this project investigated how an in-depth understanding of consumers' choice motives could help identify both consumer-relevant benefits and perceptual barriers towards HPP chilled ready meals. It did so by conducting 40 in-depth one-to-one interviews with purchasers of chilled ready meals.

Reaching out to your target audience

In this study a qualitative research technique was used to construct hierarchical value maps (HVMs), which illustrate how key product attributes are linked with consumer-relevant consequences or benefits (Figures 1a and 1b). The HVMs reveal not only what qualities consumers desire, but also the rationale behind their choices. In this way a better understanding can be gained of consumers' food decision-making processes for HPP chilled ready meals.

Figures 1a and 1b illustrate how two consumer groups, namely those at pre-family and family life stages, perceived the value propositions associated with HPP in different ways. For example, the HVMs suggest that a positioning strategy for the extended shelf life concept should focus on emphasising functional consequences, such as saving money and/or flexible meal planning, for respondents in the pre-family life stage. Although flexible meal planning was also important to respondents in the family life stage, these consumers were primarily driven by the



FIGURE 1a: Hierarchical value map of chilled ready meal consumers in the pre-family life stage (cut-off level: 4, $n = 17$). The value-added product attributes are positioned near the bottom of the map, and are linked to consumer values at the top of the map by consequences in the middle. The thicker lines represent stronger relationships between attributes, consequences and values.

psychosocial consequence 'can do other things', such as spend time with family. The strongest association was made between 'stay healthy' and 'family well being', which was further linked to the value 'duty of care' for respondents in the family life stage grouping. The values 'financial security' and 'career fulfilment' were most important to respondents in the pre-family life stage consumer group. The HVMs also identified two key abstract attributes of importance to product developers, 'more natural' and 'more homemade', which consumers would be expected to use as intrinsic and extrinsic cues to guide their food choices. More so, while the attribute 'more homemade' was connected to both the health-oriented and sensory-oriented product platforms, the attribute 'more natural' was linked to a health orientation only.

Getting the concept right

While minimally processed chilled ready meals with a longer shelf life might seem like a good idea in terms of adding value, the discussions revealed that a reduction in additives, coupled with a shelf life extension, were incompatible from the consumer's perspective. Indeed, the HVMs showed that the value-added attribute 'contains fewer additives' was strongly associated with the health orientation platform, but was not associated with the extended shelf life platform.

Education or misinformation

There is a strong argument for providing consumers with more information on products produced using novel technologies and associated benefits in order to provide them with the knowledge to make more informed food choice decisions, and to increase consumer acceptance. Initial discussions suggested that the provision of selected information on the technological process, with specific reference to a reduction in cooking times, proved beneficial given consumers' inherent beliefs in the adverse effect of thermal processing on the nutritional quality of food. However, the provision of such information also gave rise to consumer concerns with regard to the extended shelf life concept. These concerns related to perceived food safety risks associated with a reduction in thermal

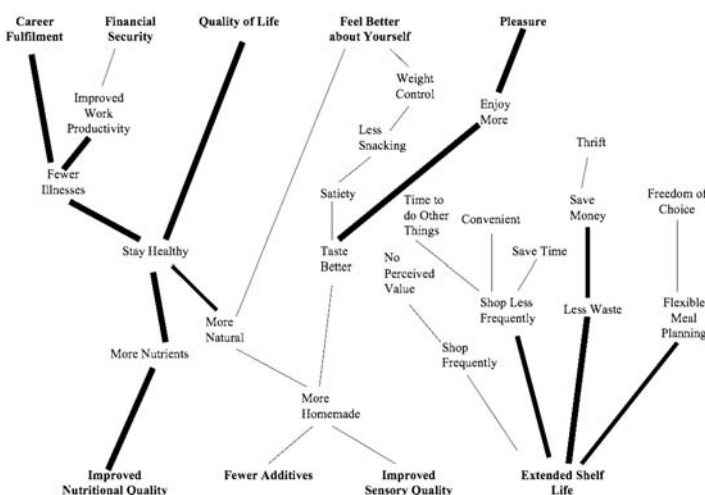


FIGURE 1b: Hierarchical value map of chilled ready meal consumers in the family life stage (cut-off level: 4, $n = 23$). (The cut-off value determines which connections between value propositions, consequences and values should be represented in the final HVMs. A cut-off value of 4, which corresponded to 70–73% of all associations, was chosen as it was found to yield the most interpretable results.)

processing during production, as well as the potential for product 'misuse' when cooking/reheating at home. These misperceptions could be attributed to consumers' indifference towards existing ready meal technologies, a poor understanding of HPP technology, and their low involvement with HPP products. This suggests that companies 'first to the market' with HPP products should focus initially on differentiating HPP chilled ready meals from existing ready meals on the basis of 'product superiority' and downplaying 'technological superiority'.

Consumer-led NPD

The research presented in this article illustrates the important role that consumer insights have to play in the NPD process in terms of exposing consumers to new technologies before going to market; assessing consumers' perceptions of different products and positioning platforms; and for the purpose of 'fast-tracking' the early stages of the NPD process. Companies that incorporate an understanding of consumers' value-creation at the concept stages of the NPD process can ultimately benefit from reduced uncertainty in NPD.

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Ensuring good food standards

Teagasc has led the way in food assurance standards and legislation implementation over two decades, explains DR GERARD BARRY, Food Training and Technical Services.

Since the 1980s the food safety and quality assurance landscape within which the food processing sector in Ireland has to operate has changed dramatically. If a comparison was made between the standards of good manufacturing practice (GMP), food safety and quality assurance evident in the food sector in the mid to late 1980s and those of the present time, the difference would be enormous. Today, it is felt that the manufacturing business environment is much more complex, and is subject to an increasing rate of change. It is worthwhile considering what has driven this change, and also to tease out how food sector companies progressed to where they are today.

It was acceptable in the '80s

The food sector in this era resided in a more relaxed environment. While the familiar pressures for volume of output and profitability were there, they were not as strident or pressurised as they are today. Requirements in terms of food product legislation were largely focused on labelling, weight control use of preservatives and, for processing standards, a strong emphasis on hygiene requirements. Regulatory bodies were mainly focused on product sample testing at retail level, and on inspection of premises and ensuring that hygiene legislation was being complied with. There was little emphasis on documentation. Many businesses – particularly smaller businesses – at the time would have had very basic documentation in place. Larger businesses would have had a more sophisticated level of documentation, and in particular the multinational businesses operating in Ireland would have had corporate systems in place aimed primarily at protecting the brand name. Businesses subject to customer audit, usually perpetrated by retail customers, would operate to a higher standard of GMP. A culture based on third-party accreditation was almost absent. There were some large businesses that had accreditation to the 'Q Mark' operated by The Irish Quality Control Association (IQCA); however, the scope of this mark related largely to hygiene and it was not food specific.

The 1990s

A number of changes in the food business environment were occurring concomitantly, to produce a powerful, compelling impetus for change in the food chain. These changes included customers becoming increasingly discerning and more inclined to pursue consumer rights through litigation if necessary. Retailers responded by taking proactive steps to defend their brand image by enhancing

Image courtesy of Bord Bia.



the standards applied to manufacturers. A significant driver for change in this decade was the BSE crisis, which had serious repercussions for the food sector in Ireland. The BSE crisis had far-reaching consequences in that it supplied definitive evidence that legislation and standards had to be improved. The crisis gave rise to changes in EU policy, whereby the consumer should come first, and that robust food legislation was a priority. Subsequently, The European Food Safety Authority and, in Ireland, the Food Safety Authority of Ireland, were established, and a comprehensive range of increasingly complex, scientifically based legislation was published from 1995 to 2006.

The climate underpinned a change in the attitude of many food manufacturers. With the advent of the ISO 9000 (International Organisation for Standardisation) in the late 1980s, many manufacturers saw accreditation to such standards as a mechanism to improve the level of food safety and quality, and to provide objective evidence of excellence. These standards had by this time gained universal acceptance in all manufacturing sectors. The dairy, beverage, cereal and sugar manufacturers decided to adopt ISO 9000 as the appropriate quality management standard for them. Teagasc, The National Food Centre (now Ashtown Food Research Centre) was uniquely placed to help companies achieve these standards. Teagasc provided specialised public and in-company courses in ISO 9000 implementation. Teagasc also managed and guided many large implementation projects for most of the dairy co-operatives, and drinks, cereal and sugar companies in Ireland. Indeed, some of the multinational operations with a base in Ireland showed leadership in that they were among the first to achieve accreditation. Certainly, Ireland in the mid-1990s rated very highly on an international comparison, in terms of number of companies registered to ISO 9000 as a percentage of the total number of companies in the economy. A similar picture was also developing in the meat sector, which was severely damaged by the BSE crisis. The path chosen in this case was unique at the time. The Irish Livestock and Meat Board (CBF – now known as Bord Bia) embarked on developing standards for the meat sector incorporating verifiable traceability to approved farms in Ireland. Teagasc, by virtue of a strong meat research programme, was also in a position to aid this development and provided a standards development service to Bord Bia. Teagasc also developed training programmes for implementation of these standards and facilitated their implementation by performing audits on behalf of Bord Bia. Before long the entire beef and pig meat sector had signed up for accreditation to these standards.

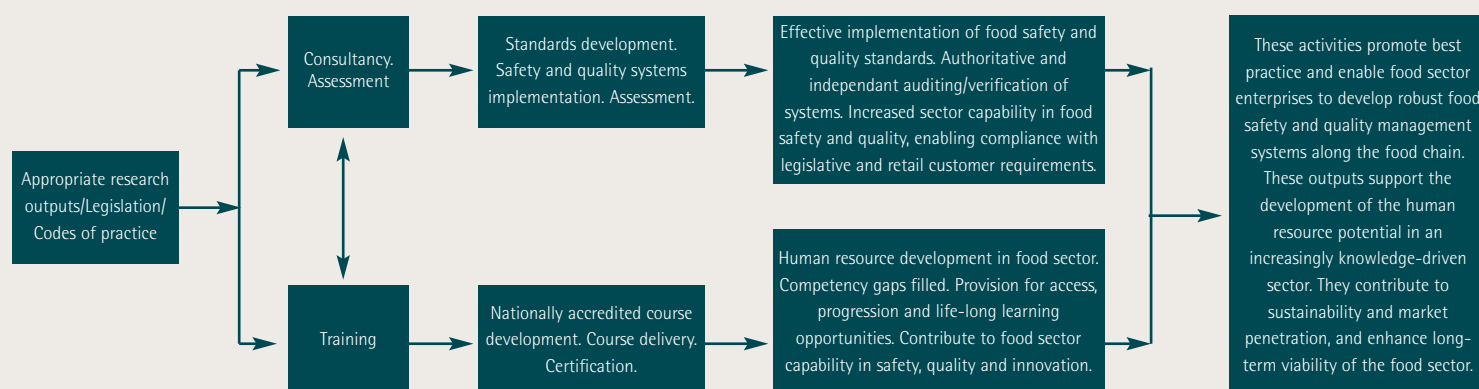


FIGURE 1: Food industry development technology transfer model.

Implementation of these standards also provided a mechanism to inculcate best practices in the meat sector and transfer appropriate research programme outputs. These developments were well embedded as an ethos towards the end of the 1990s and this is to the credit of the Irish food sector, as these accreditations were voluntary and involved a lot of self-examination, adoption of significant changes in operational activities at times, and significant costs. The other driver of change was new legislation, which focused on food safety, based increasingly on HACCP (Hazard Analysis and Critical Control Point) principles. The fundamental basis of this legislation was that it made the business responsible for demonstrating its capability to produce safe food. In the early 1990s, Teagasc was aware of the impending adoption of HACCP principles in the legislation and began to promote use of HACCP as a tool to optimise controls to assure food safety. Teagasc provided training and consulting on a large scale to the food sector, enabling companies to design and install robust food safety systems in compliance with legislative and customer requirements. During this period Teagasc began to provide HACCP and auditing training to the competent authorities, a process that continued into the next decade.

The noughties

The legislation implemented during the early stages of the last decade, referred to as 'The Hygiene Package', introduced dramatic changes governing food operators' responsibilities, and how the relevant competent authorities controlled food operations under their remit. In particular, the food chain post-farm gate had to adopt HACCP methodology. Issues adopted in the legislation included: risk assessment; traceability; responsibility for monitoring processes; and, microbiological criteria, to mention a few. Responsibility for food safety, and the ability to demonstrate this, was placed squarely on the food business operator. During this decade, third-party accreditation had become much more widespread and, in many cases, a prerequisite for doing business with the retail multiples. Third-party accreditation has become part of the culture of the food sector. All standards now fully embrace HACCP-based food safety and, additionally, quality requirements. There has been a proliferation of standards such as ISO 22000, FEMAS (Feed Materials Assurance Scheme), British Retail Consortium and Bord Bia standards (which have extended in scope to include egg packing, pork, sheep and poultry meat), other retail standards, etc. Many companies may have more than one standard in place and see accreditation as driving improvement. Standards of operation are currently very high.

In Teagasc we have been very active in providing practical help and supporting the food sector in implementing these changes. Teagasc has had a significant cumulative impact on the food sector capability in food safety, quality management and the practical interpretation of legislation over the last two decades. At Teagasc, a team of some 20 dedicated industry advisors are backed by a food research programme of some 50 staff. Our industry support activity in these areas is depicted in **Figure 1**. In essence, appropriate food research outputs from within the Teagasc research programme and other sources, food legislation and codes of practice are incorporated into our training, consulting and assessment activities to embed this knowledge in food sector companies. The information is disseminated via training, consulting and assessing in food safety and quality management systems. Food companies may access our training via our public training programme or by requesting training (sometimes bespoke training) on their own site, or requesting support in the form of consulting or assessment. For more information on our industry support, see www.teagasc.ie/ashtown/fid/.

The future – 2010–2020

It is now time for crystal ball gazing, and there are several issues that I believe will impact on the food sector during this period. Legislation implementation in relation to risk assessment and microbiological criteria will continue to raise questions that must be answered. This will drive food safety research. Previous decades have brought new food safety hazards and no doubt the future will too. Provenance of foods and changes in labelling will increasingly be an issue. A sustainable and environmentally friendly food chain, including carbon footprinting, will also feature. Food safety and quality standards will continue to become increasingly complex and I hope we will see consolidation in standards going forward.



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Cheese research: for industry diversity, quality, efficiency

With cheese production in Ireland at an all-time high, researchers at Teagasc Moorepark continue to look for innovative ways to improve quality for producers and consumers.

Cheese production in Ireland, the vast majority of which is exported, has increased at a dramatic rate from about 80,000 tonnes per annum in 1995 to 175,000 tonnes per annum in 2008 (**Figure 1**). Exports alone were valued at €612m in 2008 (Bord Bia). Drivers of growth have included decreased intervention support for dairy commodities and downward trends in global dairy commodity prices, coupled with greater international price stability for cheese, a global increase in cheese consumption, the high end use versatility of cheese, the potential for significant added value, and its potential as a profitable outlet for surplus milk fat.

Innovation for changing markets

Traditionally, Irish cheese production focused on Cheddar (about 80% of production), which has accounted for up to 40% of retail cheese exports to the UK cheese market (a market estimated at 600,000 tonnes and valued at £3.6bn stg). However, cheese markets are fast evolving; the Cheddar market in particular is a mature market and is predicted to grow more slowly than for other cheese types, such as semi-soft, semi-hard and branded specialty continental-type cheeses (Strategic Development Plan for the Irish Dairy Industry, 2003). Furthermore, a significant proportion of Irish Cheddar is sold through UK multiples, often as own label products with associated lower margins.

Research demands

This shift in market focus has required manufacturers to be highly innovative in the development of new products with specific properties for target markets; to achieve greater diversity and efficiencies and also to lengthen the manufacturing season, but yet maintain optimum product quality. Approaches to this include the following:

- optimisation of manufacturing efficiency and yield;
- development of functional and ingredient cheeses targeted for use in food service sectors, or of ingredient cheeses for secondary processing applications;
- diversification of product profile and targeting of markets for continental-type cheeses;
- enhancement of flavour profiles through microbial and enzymatic approaches; and,
- improvement of the nutritional profile of cheese through reduction of fat and sodium content and development of bioactive properties.

However, achievement of these goals presents a technical challenge to the cheese manufacturers in that it requires a detailed knowledge of the physico-chemical, biochemical and microbiological complexities of cheese manufacture and ripening, and an understanding of how manipulation of process variables, combined with variability of raw materials, impacts on product quality, flavour and functionality. The cheese research programme at Moorepark Food Research Centre is well positioned to provide such a platform and already interacts with both the Irish and international cheese industry to achieve greater development through provision of a scientific and technological capacity.

Research to underpin exploitation of markets for continental-type cheeses

One example of such interaction concerns exploitation of markets for continental-type cheeses. In excess of 10,000 tonnes of Swiss-type cheeses are produced per annum in Ireland, the vast majority of which are exported to continental European and US markets. Recently, Irish cheese producers have invested substantial capital expenditure in the installation of new manufacturing plant to target those export markets. Swiss-type cheeses (e.g., Emmental, Jarlsberg) are of high importance internationally with approximately 466,000 tonnes of Emmental and 142,200 tonnes of Swiss-type cheese produced in Europe and the USA, respectively, per annum.

Swiss-type cheeses are identifiable by their characteristic eyes and a nutty sweet flavour, and by a particularly complex manufacture and ripening process in which two major desirable fermentations occur:

1. Lactic acid fermentation, where lactose is converted to L-lactate and/or D-lactate, which influences cheese quality because of its effects on curd pH and hydration, calcium levels, the inhibition of other bacterial growth, and in providing substrate for the subsequent propionic fermentation; and
2. Propionic acid fermentation, where *Propionibacterium freudenreichii* bacteria produce metabolites (propionic acid and acetic acid) that are essential to the development of the characteristic nutty sweet flavours, and also produce CO₂, which, when levels exceed saturation point in the cheese curd, leads to eye formation.

However, Swiss-type cheeses are particularly susceptible to defects relating to poor or irregular eye formation and development of slits and splits in the cheese texture, and secondary fermentations, which lead to downgrading of cheese in export markets (**Figure 2**). This is a sporadic and widespread problem in Swiss-type cheeses produced throughout Europe and the US, and Irish cheeses are no

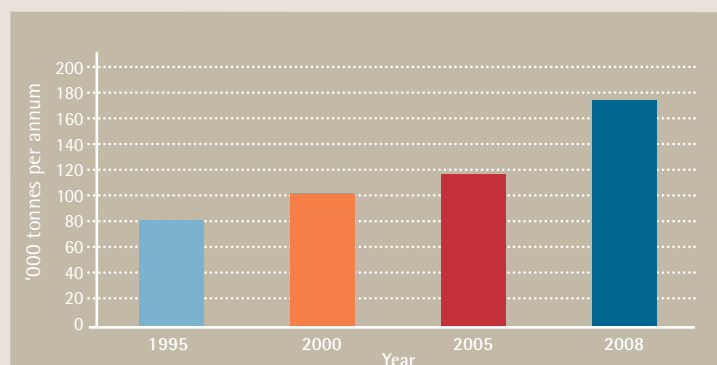


FIGURE 1: Cheese production in Ireland (ZMP-Marktbilanz Milch, 2008, Central Statistics Office, 2009).

exception. Split defect is associated with an excessive production of gas or an unsuitable cheese body, which cannot accommodate gas produced, while secondary fermentation is a further production of gas after the desired propionic fermentation has taken place.

Factors associated with these defects may be defined under: curd rheological behaviour (including manufacture processes, acidification, intact protein content and proteolysis, seasonality of milk supply, and ripening or storage temperature and duration); or, factors leading to overproduction of CO₂ (including milk microflora, and propionic acid bacteria – in particular strains with high aspartase activity and ability to grow at low temperatures, stimulation of propionic acid fermentation by protein metabolites produced by lactic acid bacteria, facultatively heterofermentative lactobacilli and other sources of gas, including butyric acid fermentation) (Daly *et al.*, 2010).

A study is currently in progress at MFRC to determine and quantify variability in key compositional, biochemical, microbiological, rheological and quality attributes of Swiss-type cheeses produced from a seasonal Irish milk supply. Preliminary results show fluctuations, in particular proteolytic indices and microbial profiles, to be of specific interest. It is already planned to counter these fluctuations at industrial level through minimising the effect of interactions between season of manufacture and specific manufacture and ripening processes. However, it has also highlighted the need to specifically clarify:

1. the role of primary proteolysis on the ability of cheese texture to accommodate gas production; and,
2. the application of facultatively heterofermentative lactobacilli in cheese to control excessive propionic acid fermentation through either reductions in levels of certain proteolytic products or through metabolism of citrate to formate, of which the latter exerts an inhibitory influence on the propionic acid fermentation.

Discussions are ongoing with potential EU partners to progress a joint proposal to pursue opportunities for EU funding to undertake further research in this area under the 7th Framework programme.

Research to evaluate the potential of commodity products to enhance cheese yield and low fat cheese texture

Other approaches to underpinning industrial development through scientific innovation are also under investigation. Buttermilk, a by-product of butter making, constitutes the serum phase of cream along with milk fat globule membrane (MFGM) components released during the emulsion break point when



FIGURE 2: Swiss-type cheese with split defects produced from a seasonal Irish milk supply.

butter is being formed. Buttermilk is usually spray dried or used directly as an ingredient, e.g., in baking applications, and has been considered a low value added material. However, as MFGM contains a mixture of proteins, glycoproteins and phospholipids, all of which can act as emulsifiers, there has been growing interest in its potential for use to increase cheese yield through retention of higher moisture levels and the potential reduction of fat losses during cheese manufacture.

Furthermore, as cream is subjected to high thermal processing during butter manufacture (e.g., 91°C x 2 min), such treatments can result in denaturation of the whey protein fraction, which may result in increased whey protein retention during cheese manufacture, reduced aggregation of casein micelles, disruption of continuity of gel network, increased water binding and, thus, the potential to ameliorate poor texture properties of reduced fat cheeses.

A project is currently commencing at MFRC to undertake a systematic investigation of the effect of fortification of cheesemilk with concentrated buttermilk/buttermilk powder on cheese yield and texture, and thus to investigate whether this commodity product may be used to increase cheese yield efficiency and enhance low fat cheese texture.

In summary

The cheese research programme at MFRC, in striving for excellence in science, is well positioned to underpin growth in the Irish dairy industry through developments in diversity, quality and efficiency.

This research is funded by the Dairy Levy Trust and by members of the Irish Dairy Industry.

Reference

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'Omics' for better breeding

Transcriptomics and metabolomics are being used as methods to investigate stress in perennial ryegrass by researchers at Teagasc Oak Park Crops Research Centre in collaboration with the Scottish Crops Research Institute.

In recent years, DNA-related experimental approaches known as genomics have been used to speed up traditional plant breeding programmes. On some occasions, however, genomics are not sufficient to accelerate the progress in identifying suitable DNA markers for selection. Genomics methods for selection and breeding can be complemented by a range of other 'omics' techniques: transcriptomics (large scale study of the expression levels of mRNAs in a given cell population); proteomics (large-scale study of protein structures and functions); and, metabolomics (systematic study of small-molecule metabolite profiles). Transcriptomics analyses the transcribed genomic information at RNA level for a certain condition and time point in a cell. Systematic and comprehensive approaches aimed at investigating the functions of genes are necessary. Studies of the transcriptome and proteome have been used in functional genomics (a research field that aims to understand the relationship between a genotype and its phenotype), but often do not provide complete information on how changes in the levels of mRNA or the proteins influence biochemical pathways. A change in the levels of mRNA cannot be used to reliably predict the change in the levels of potentially translated proteins, and similarly the levels of proteins in the cell do not necessarily correlate with their putative activity. The emergence of metabolomics as a methodology to study functional genomics may allow a comprehensive unbiased analysis of the downstream effects of changes in mRNA and protein levels by identifying and quantifying all the measurable metabolites in an organism.

Omics tools

In order to understand the function of annotated genes (a previously unknown sequence is enriched with information regarding its structure and function), functional genomic approaches often introduce changes into the environmental system or in the genetic profile, and monitor the consequent response of the transcriptome, proteome or metabolome. Metabolomics as a tool for functional genomic studies is a particularly comprehensive approach for studying any potential metabolic pathways involved, and it is being extensively used in plant sciences, for example: (a) to study transgenic plants; (b) to establish the basis of differences between plant varieties; and, (c) for functional approaches regarding the plant response to environmental stresses.

Environmental stresses

Environmental stresses are the result of conditions that hamper the optimal growth and development of organisms (Figure 1). These can be classified according to their origin as either biotic or abiotic stresses. Biotic stresses are the result of biological interactions with competing organisms, predators, pathogens or parasites, while abiotic stresses (non-biological) are caused by non-optimal levels of the physical components in the environment.

Stresses from different origins can often result in similar consequences for the cell, for instance, the oxidative damage resulting from a wide range of stresses such as drought, pathogen attacks and high concentrations of heavy metals in the environment. Plants cannot change their spatial position, and thus they sometimes have to cope with unfavourable environmental conditions. Their survival depends on acquired tolerance mechanisms. These mechanisms are responsible for overall improved stress tolerance, which may allow the plants to survive and recover from unfavourable conditions. Many metabolites such as compatible solutes (compounds that reduce the impact of osmotic stress) like trehalose, proline and fructans increase cell tolerance to a multitude of stresses, whereas some metabolites, particularly in the secondary metabolism, respond to very specific conditions. Therefore, components of the metabolome may have a crucial role in the acquired tolerance mechanisms, and these can be monitored simultaneously by metabolomics approaches.

Monitoring abiotic stress in ryegrass

We were interested in using a combined transcriptomics and metabolomics approach to monitor the response of perennial ryegrass (*Lolium perenne* L.) upon exposure to environmental stress conditions. A set of physiological experiments was designed to investigate the response of perennial ryegrass to different nitrogen, phosphorus, and water/drought stress conditions (Figure 1). We have used partial transcriptomics studies involving the construction of expressed libraries (collection of short sequences of transcribed cDNA sequences) for certain traits and whole transcriptomics analysis, while metabolomic analysis has mainly been carried out by using gas chromatography-mass spectrometry (GC-MS) profiling.

Water and drought stress

Although currently water/drought stress seems to be a minor issue in Irish grasslands, predictions for climate change for the north and west regions of Europe seem to suggest an increase in weather extremes, thereby exacerbating water stress with swings from too much to too little. Hence, we need to look into genetic variation to withstand these stresses.

Comprehensive metabolic profiling was carried out to uncover mechanisms involved in the plants' response to drought stress. When leaf and root material from two genotypes, differing in their response to drought stress, were analysed by GC-MS, a clear difference in the metabolic profiles of the leaf tissue under water stress was observed (Figure 2). Differences were principally due to a reduction in fatty acid levels in the more susceptible genotype and an increase in sugars and compatible solutes in the more tolerant genotype. The sugars raffinose, trehalose, glucose, fructose and maltose were significantly increased. Raffinose was identified as the metabolite with the largest accumulation under drought stress in the more tolerant genotype and may represent a target for selection for superior drought tolerance in perennial ryegrass. The metabolomics approach was combined with a transcriptomics approach in the drought stress tolerant genotype, which has identified genes in perennial ryegrass that are regulated by drought stress.

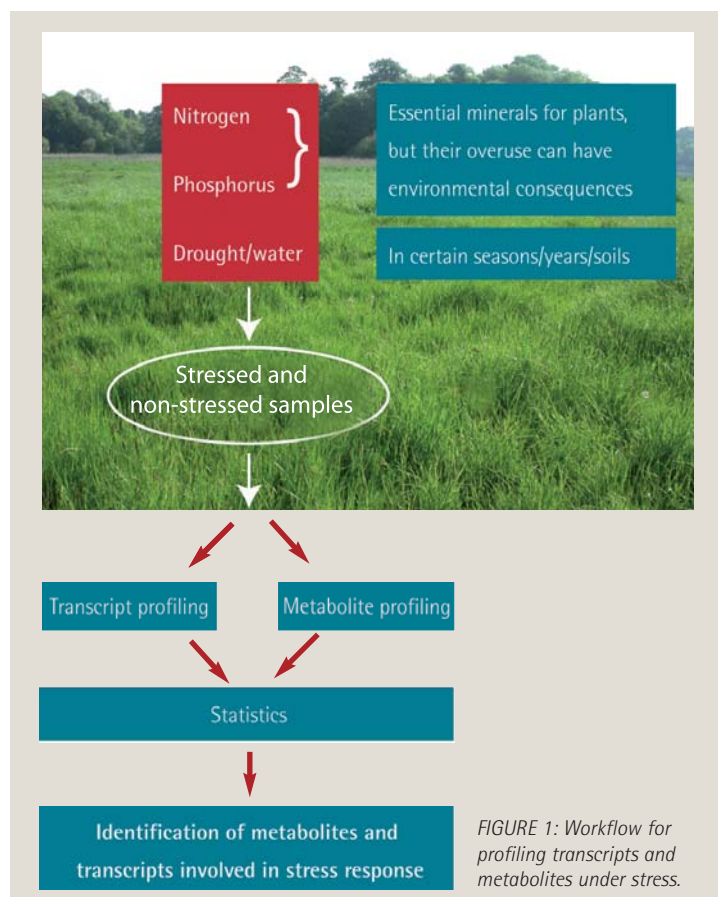


FIGURE 1: Workflow for profiling transcripts and metabolites under stress.

Nutrition stress

Water limitation is one of the major abiotic factors affecting plant growth, but so is nutrition, particularly nitrogen and phosphorous limitation. A major proportion of the Irish agricultural land area is devoted to grassland and maintaining adequate nutrient supply in this area is prohibitively costly, besides being regulated under different directives (e.g., Nitrates Directive). If used in surplus, nutrient supplements may contaminate waters and cause a threat to biodiversity. GC-MS-based profiling of leaf and root tissues, in combination with whole transcriptome profiling, was carried out under different phosphorous supply levels. We found several upregulated transcripts under poor phosphorus supply conditions that are involved in general stress response mechanisms, while other transcripts seem to be involved in a much more specific response to phosphorous limitation, such as phosphate transporters, acid phosphatases and transcription factors. The metabolite profile revealed an increase in sugar levels in root tissues and a decrease in some of the amino acids derived from pyruvate, suggesting a reconfiguration of the metabolism. Both leaf and root tissue metabolite profiles seem to suggest that there is a change in source-sink relationship between these two tissues under low phosphorous supply.

Benefits to industry and future work

One of the long-term objectives is to develop technically less demanding assays for the metabolites that have been identified to have a significant role under stress conditions, which can be used in more applied research programmes. A

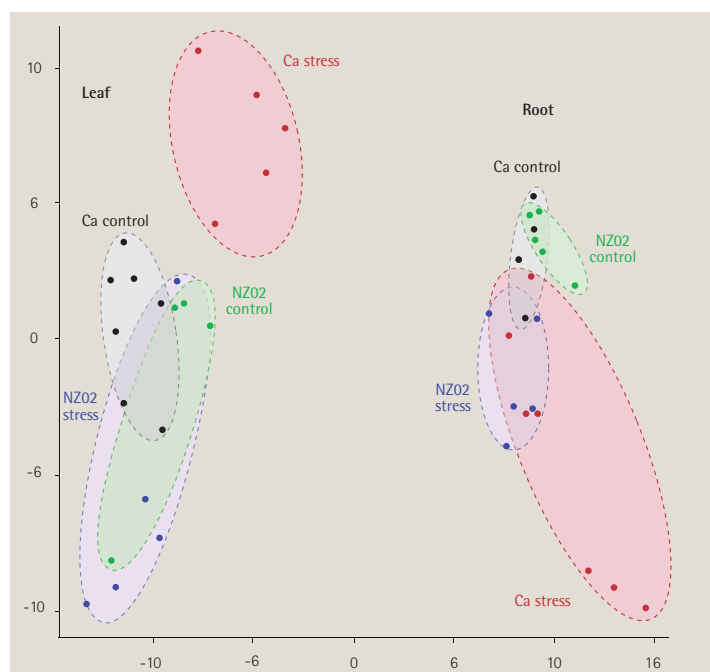


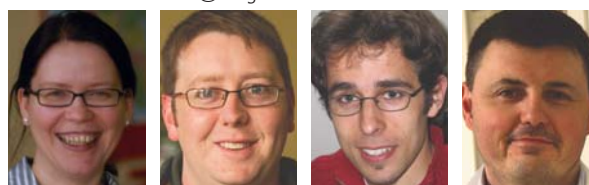
FIGURE 2: The GC-MS data from control and drought-stressed ryegrass lines subject to principal component analysis to determine the effect of drought on the leaf and root metabolomes of a drought-susceptible (Ca) and more tolerant (NZ02) ryegrass line. As expected, clear differences in metabolic profiles can be seen between leaf and root tissue but we also see that the leaf tissue of the drought-susceptible ryegrass line (Ca) has a clearly separated metabolic profile under drought stress. In contrast there is no clear separation between control and stress in the more drought-tolerant line (NZ02).

second objective is to develop robust diagnostic assays, which can be applied with ease to identify significantly up/down-regulated transcripts. Such facile and utilitarian functional tools will prove invaluable in assisting breeding programmes to meet the future needs of forage production.

Acknowledgements

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Protecting environmental water quality from microbial pathogens

Microbial pathogens in waters can pose a significant risk to human health. Researchers at Johnstown Castle and collaborating universities are investigating the fate and transport of these pathogens in the environment for the protection of waters.

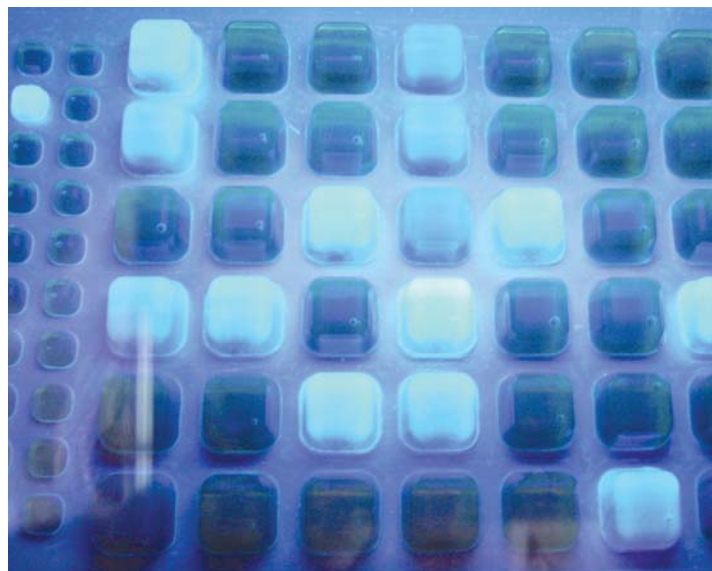


An agricultural catchments hydrometric sampling site.

Microbial pathogens in drinking and recreational waters can constitute a human health hazard. Microbial contamination of water is common in Ireland, and outbreaks such as the *Cryptosporidium* outbreak in Galway in 2007 (in which there were more than 240 reported illnesses) have both health and economic implications. Of particular concern are small drinking water supplies, commonly derived from groundwater, sources of which often receive inadequate or no treatment. A large number of potential contributing sources of pathogens exist, including landspreading, septic tanks, wastewater treatment plants, grazing animals, farmyards and wildlife. Understanding how microbial pathogens from these sources survive and move in the environment is critical for the development of risk assessment and mitigation measures for the protection of waters.

Pathogen transport

Landspreading of animal manures and slurries is an important mechanism for nutrient recycling in agricultural systems, with a resulting economic benefit. Animal-derived organic manures can contain a large range of pathogenic microorganisms, including *E. coli* H7:O157, *Cryptosporidium* spp. and *Salmonella* spp., which can pose a health risk should they be transported to waters. An



E. coli testing using a quantitative fluorescent method.

important function of soils is to retain microbial pathogens, thereby protecting drinking and recreational waters. As such, understanding the factors influencing the fate and transport of pathogens in top- and sub-soils is of importance for the protection of underlying groundwater. Research conducted at Johnstown Castle has investigated bacterial transport in grassland soils both *in situ* at field sites and in field lysimeter (soil monolith) units.

Results indicate that preferential (by-pass) flow is the main mechanism of bacterial transport in Irish grassland soils and that earthworm channels are the main flow pathways. Preferential flow occurs when infiltrating water from the surface bypasses the soil matrix, through pathways in the soil profile, potentially causing rapid leaching of nutrients, pathogens or other contaminants to ground and surface water. Soil type is of major importance in governing the vertical transport of bacteria through soil, with the more poorly drained soils posing the greatest risk of bacterial transport in the first metre of soil. In addition to soil/sub-soils, a groundwater risk matrix was developed by researchers in NUI Galway incorporating further geological and hydrogeological factors contributing to groundwater protection, to assess the risk of contamination to groundwater. Aquifer vulnerability to microbial contamination was ranked while incorporating pressure magnitudes and pathway characteristics. It was found that severely



Tracing pathogen transport pathways in soil using blue dye at field sites.

vulnerable aquifers in karst areas responded rapidly to environmental stresses, which was evident from excessively high pathogen loads in comparison to less vulnerable aquifers. This matrix is key to determining the vulnerability of groundwater supplies and can be applied to any geological setting.

Survival in soil

The survival of pathogenic microorganisms in soil remains a major unknown in the development of accurate quantitative microbial risk assessment models for the protection of water quality. A wide range of factors influence pathogen survival times in soils and these include: temperature; pH; moisture content; nutrient availability; soil management practices; soil structure and texture; moisture content; oxygen status; and, pathogen type. One of the most poorly understood factors is the impact of the indigenous soil microflora on pathogens in soils. The soil microflora may have a substantial role in reducing pathogen numbers through antagonistic interactions, such as predation and competition for available resources. Joint research underway between Johnstown Castle Environment Research Centre and Cranfield University in the UK is currently investigating the rate of decline of viable pathogen populations in soil, and the relationship between this decline and the nature of the indigenous microbial communities. In

addition, research investigating pathogen survival in Irish soils conducted at Johnstown has found that *E. coli*, which is widely used as an indicator of faecal contamination in waters, can become integrated into the indigenous microbial community in some soil types and can persist for more than nine years. This has important implications for the indicator status of *E. coli*, suggesting that the presence of *E. coli* in surface or groundwaters may not be indicative of recent faecal contamination. It also suggests that *E. coli* persistence may be favoured in some soil types and these soils may represent a greater risk of bacterial leaching.

Microbial source-tracking

One of the principal difficulties in improving the microbial quality of water is that distinguishing the source of contamination in the environment is often highly complex. So, how do we know which potential contaminant source is impacting on water quality? Microbial source-tracking is one such approach that is increasingly being used to distinguish host-specific contributions of faecal contamination to waterbodies, thus helping resolve these unknown sources. This information can, in turn, guide decisions regarding the appropriate corrective measures for affected waters. Building on previous source-tracking research performed by NUI Galway on groundwater supplies, research is now being carried out as part of the Teagasc Agricultural Catchments Programme. The aim of the research is to define the sources of a bacterial group derived from faecal matter, *Bacteroidales*, based on its characteristics, within Irish agricultural catchments where the potential for both point and diffuse bacterial pathogen transfers exists from multiple sources. The relative contribution of sources will also be assessed during storm and non-storm periods.

Acknowledgements

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The fate of slurry nitrogen in grassland

Researchers at Johnstown Castle Environment Research Centre, in collaboration with UCD, have been looking to see if the nitrogen fertiliser replacement value (NFRV) of 40% for N contained in cattle slurry under the Nitrates Directive is achievable under Irish conditions.

With fertiliser prices being a significant farm income cost, there has been a renewed interest in optimising the utilisation of nutrients contained in cattle slurry. The Nitrates Directive regulations impose limits on nutrient inputs in fertilisers. Irish legislation for compliance with the Nitrates Directive assumes a nitrogen fertiliser replacement value (NFRV) of 40% for nitrogen (N) contained in cattle slurry and additional chemical fertiliser N allowances are set to supplement this assumed recovery. However, this NFRV is relatively low compared to countries such as The Netherlands and Denmark, where NFRVs for cattle slurry on grassland are set at 50 and 70%, respectively, and there is pressure on Ireland to reach the same targets. Therefore, Teagasc and UCD took on a research project, co-funded by the Department of Agriculture, Fisheries and Food (DAFF), to determine what N recoveries can be achieved in Ireland and how we can optimise the N utilisation of cattle slurry in grassland.

Slurry N dynamics

Approximately 50% of N in slurry is in mineral form (mainly ammonium originating from urea in urine). This N is available for plant uptake directly after application. However, up to 90% of this mineral N can be lost through ammonia volatilisation in the days immediately after land application. The losses from this mineral N fraction can be limited by using low emission application techniques such as trailing shoe application (slurry applied in bands to the soil surface) or injection (slurry injected into slits in the soil). Ammonia volatilisation can also be decreased by applying slurry at a time when conditions are less conducive for ammonia volatilisation, i.e., overcast conditions, cool temperatures and low wind speeds during the days following application. Although these measures have a proven effect on reducing ammonia volatilisation, their effect on N recovery in herbage has been less evident.

The remaining 50% of slurry N is in organic form (originating from faecal N), which needs to be mineralised in the soil before it can be taken up by the herbage. Some of this organic N is taken up by herbage in the year of application, but the bulk stays in the soil and may become available at a later stage. Very little is known about when and how much of this organic N is released and, therefore, this is usually not taken into account when determining the nutrient value of slurry.

¹⁵N labelling

As part of a larger project on the utilisation of slurry N, we used novel ¹⁵N stable isotope labelling methods to trace the fate of slurry mineral and organic N through the plant and at different soil depths, and to calculate losses (**Figure 1**). The two main objectives of this study were:

- 1) to determine the effect of application method and timing on the recovery of mineral slurry N: and,
- 2) to better predict the fate of slurry mineral and organic N in plant and soil in the years following application, i.e., to investigate the long-term effect of slurry application.

Improving the recovery of slurry mineral N

We found that when slurry was applied with low emission application techniques (trailing shoe instead of splash plate) the losses of mineral slurry N were lower, and a higher proportion of mineral slurry N was taken up by plants. Applying slurry at a time when potential volatilisation is low (spring as opposed to summer application) had the same effect. This is in line with results from research in Johnstown Castle based on conventional agronomic field trials and direct ammonia volatilisation measurements. Additionally, trailing shoe

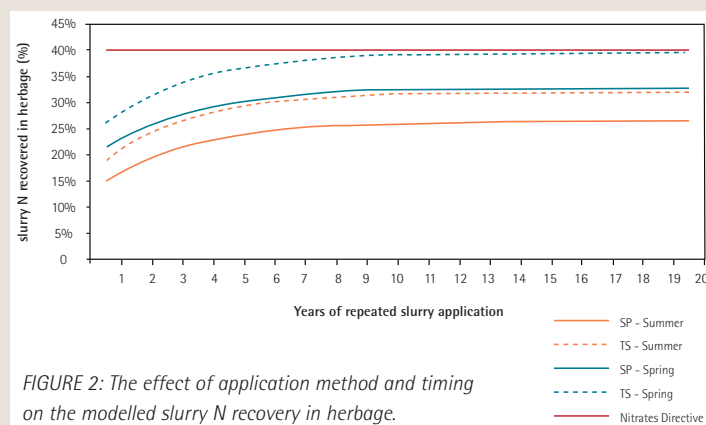


FIGURE 2: The effect of application method and timing on the modelled slurry N recovery in herbage.

FIGURE 1: Preparing samples for ^{15}N analysis.

application increased the recovery of mineral slurry N in the soil by the end of the year, suggesting that there may be a knock-on effect on plant N availability in following years.

Residual recovery of slurry organic and mineral N

The ^{15}N work showed that approximately 12% of the organic N was recovered in the first year after application and another 5% was recovered in the following year. By the end of year two approximately 40% of the organic slurry N remained in the soil.

When we sum both the mineral and organic N in slurry, the recovery in the first year may vary from as little as 15% for slurry applied in summer with a splash plate to as high as 26% for slurry applied in spring with a trailing shoe (See also **Figure 2**, year 1). The maximum recovery of slurry N in year 2 was calculated to be 4% of the total slurry N applied, which is almost negligible from an agronomic point of view. However, at the end of year 2, up to 37% of the slurry N applied was still present in the soil, and this is likely to become available for plant uptake in subsequent years.

Predicting the recovery of slurry N

On many farms, it is general practice to apply slurry on the same fields year after year. Therefore, we used the ^{15}N data to develop a model to predict the residual effect of slurry N applied onto the same field on a yearly basis. The relative degradation rate of slurry N in each year is calculated as a percentage of the N remaining in the system at the end of the previous year, and was on average 25%. This relative degradation rate determines how long it takes for all the slurry N to be mineralised, or how many years of repeated application it would take to reach the maximum recovery of slurry N (Figure 2). Of this 25% N that becomes available each year, only one-quarter was taken up by the herbage and the remainder was lost to the environment. Model application showed the maximum cumulative residual recovery was reached after approximately 10 years of repeated application and was 12% for splash plate application and 14% for trailing shoe applied slurry. As a result, the total cumulative recovery of slurry N varied from 27% for splash plate application in summer to 40% for trailing shoe application in spring.

These long-term predicted recoveries are substantially lower than those reported

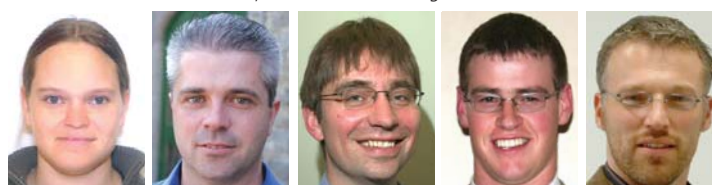
in the Netherlands and Denmark. This is partly related to the obligation to use slurry injection in those countries, which would increase the first year recovery by at least 10%. For most Irish grasslands, injecting slurry appears to be unsuitable because of the high stone content of soils and undulating topography. Additionally, the high rainfall conditions in Ireland have a negative impact on the ratio of the available N utilised for plant growth and results in relatively large losses. During the experimental period (2007 and 2008), weather conditions were unusually wet, particularly in summer, which is likely to have exacerbated losses to levels well above average.

Implications for industry

In summary, this research indicates that with optimal management of application timing combined with the use of low ammonia emission application methods, the target NFRV of 40% under the Nitrates Directive is achievable. However, the target of 40% reflects the maximum level that is achievable under Irish conditions, and will not be consistently attained at farm level because of restrictions in soil trafficability that impair the optimisation of application timing, particularly in the spring period.

This research is financially supported under the National Development Plan, through the Research Stimulus Fund, administered by the Department of Agriculture, Fisheries and Food. Teagasc and UCD also provided funding.

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A novel vaccine delivery system

A novel intranasal vaccine delivery system is being developed and tested by DR BERNADETTE EARLEY of Teagasc Animal Production and Grassland Research Centre, Grange, and DR MICHAEL WELSH of the Agri-Food and Biosciences Institute, Northern Ireland.

Respiratory disease in young calves is a major health and welfare problem, in which viruses such as bovine respiratory syncytial virus (BRSV) and bovine para influenza-3 virus (BPI-3) are frequently the primary agents involved. Subsequent bacterial involvement is normally treated by administration of antibiotics. The development of effective vaccines that stimulate long-lasting immunity at the respiratory mucosal surface would be a major step forward in the control of these diseases. Conventional vaccines against bovine respiratory viruses generally offer only limited protection, which is often short-lived. Polymeric microparticle vaccines potentially offer a useful alternative, since there is evidence that uptake of orally administered microparticles is by the microfold (M) cells of the gut-associated lymphoid tissue, and it has been suggested that uptake by the nasal route is effected by a similar process involving the nasal-associated lymphoid tissue (NALT). This latter approach was investigated in a study at Grange. In the study, immunoglobulin (Ig)A and IgG responses to a model immunogen (i.e., causes an immune response) called ovalbumin (OVA), encapsulated in poly(DL-lactide-co-glycolide) (PLG) microspheres (PLG-OVA) and delivered intranasally to calves, were investigated in nasal and sera samples, respectively. IgA antibodies are present in the respiratory tract and protect the lung surfaces that are exposed to outside foreign substances. Approximately 10–15% of the antibodies present in the body are of the IgA sub-type. IgG antibodies are the most common immunoglobulins (75–80%) in the circulation and play an important role in fighting bacterial and viral infections.

Microencapsulation

Drugs can be encapsulated in the PLG polymer so that when they are administered the polymer coating breaks down slowly, allowing the drug to be released over a long period. In this study, microparticles containing OVA were prepared using a polymer with a molecular weight of 40–75kDa and a lactide/glycolide ratio of 50:50 (Sigma-Aldrich Co. Ltd., Poole, UK). The microspheres were prepared by a solvent evaporation technique from a water-



Nasal sponge that is used to collect nasal fluid.

oil-in-water (w/o/w) emulsion. The resulting emulsion was then homogenised and the microspheres were freeze dried and stored at -20°C .

Optimisation of dose of microencapsulated antigen

Three groups of eight calves (Holstein-Friesian), approximately eight months old, were each administered intranasally: (1) 0.5mg; (2) 1mg; or, (3) 5mg of PLG-OVA. Five weeks after primary immunisations, all groups were re-immunised with the same amount of encapsulated antigen. Nasal washings and serum samples for IgA and IgG analysis were taken at weekly intervals for 10 weeks. Clotted blood samples and nasal fluids were collected the morning before primary immunisation and then at predetermined time points after primary and secondary immunisation. Nasal fluids were collected by insertion of a sponge into the nostril for three minutes, and the absorbed fluid was extracted using a 20ml syringe. The nasal fluid was centrifuged at 2,000g for five minutes at 4°C to remove aggregated mucus and stored at -20°C until required for testing.

Results

The release of encapsulated OVA from PLG microparticles *in vitro* is shown in **Figure 1**. The concentration of OVA in the supernatant was observed to increase progressively in an almost linear fashion over the length of the experiment (10 weeks) following an initial burst release of protein (34% of the total protein load) in the first 72 hours, and 98.5% of the total protein was released during the 70-day study.

Mean levels of OVA-specific IgA antibodies in nasal fluid were observed to increase following intranasal inoculation of the microspheres. Significant OVA-specific IgA levels were detected only after the second immunisation for 0.5mg (weeks 8 and 9) and 1mg (weeks 7 and 9). At no time in the 10-week study did the levels of OVA-specific IgA generated by the three doses vary significantly from each other. As with the OVA-specific IgA levels observed in the nasal secretions, only the 0.5mg and 1mg doses of antigen generated significant



Nasal sponge inserted into the calf's nostril.



The contents of the nasal sponge are placed in a sterile syringe and are collected in a sterile tube for immunoglobulin (IgA) analysis.

levels of circulating OVA-specific IgG in the serum. The 0.5mg dose elicited levels significantly different from the pre-inoculation sample at week 2, whereas the 1mg dose generated elevated levels at weeks 1, 2 and 10.

Conclusion

The immunogenicity of proteins encapsulated in PLG microspheres has not been investigated to any extent in large animal models. In this study, IgG and IgA responses to OVA encapsulated in microspheres was investigated following intranasal inoculation into calves. Scanning electron microscopy and flow cytometric analysis demonstrated a uniform microsphere population with a diameter of $<2.5\mu\text{m}$. OVA was released steadily from particles stored in phosphate buffer saline (PBS) almost in a linear fashion, and after four weeks many particles showed cracks and fissures in their surface structure. Following

intranasal inoculation of calves with different doses of encapsulated antigen, mean levels of OVA-specific IgA were observed to increase steadily, but significant differences in IgA levels (from the pre-inoculation level) were only observed following a second intranasal inoculation. With 0.5mg and 1mg doses of antigen, OVA-specific IgG was also detected in serum. OVA-specific IgA persisted in nasal secretions for a considerable period of time and was still detectable six months after inoculation in the animals.

The study of microparticle vaccines in large animal models is still at an early stage; however, the results of this study demonstrate proof of concept, and show that this approach induces local immune protection in the lung and consequently the induction of significant and long-lasting immunity in the respiratory tract of calves following intranasal vaccination.

Acknowledgement

Teagasc acknowledges with gratitude the support of National Development Plan funds in financing this research.

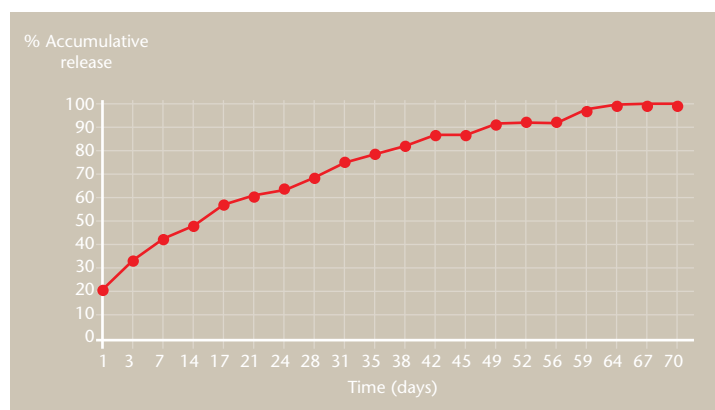
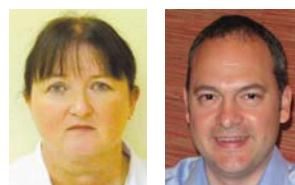


FIGURE 1: In vitro release of ovalbumin (OVA) from PLG microparticles over time. Approximately 20mg of PLG-OVA was suspended in sterile phosphate buffer saline (PBS) containing 0.02% NaN_3 in an orbital shaker at 37°C for 70 days. The PBS was removed at predetermined time points and analysed for protein content.

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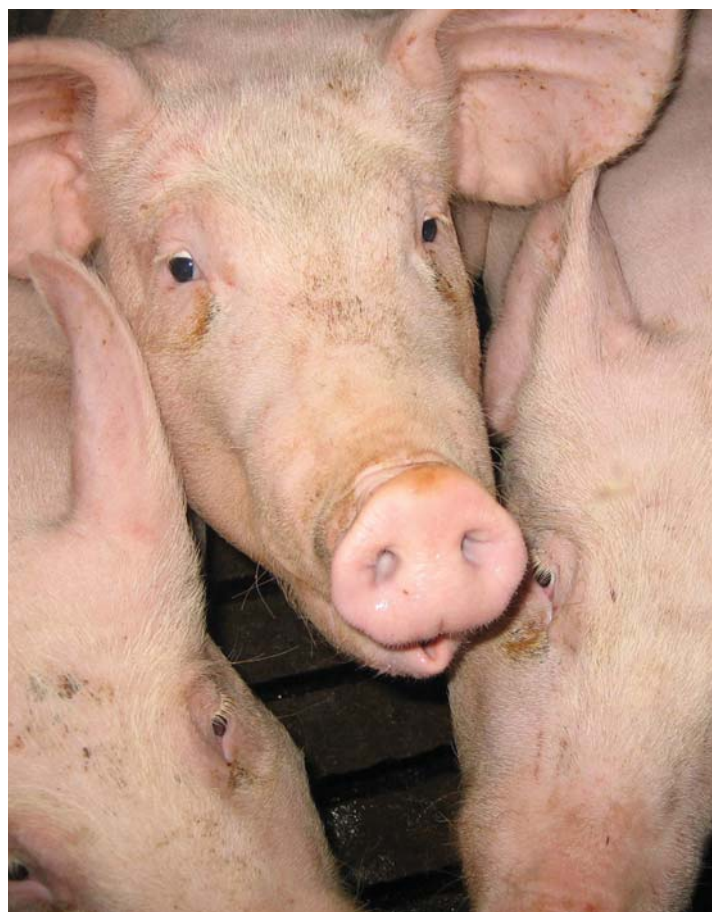
Grouping and slaughter management of entire male pigs

A collaborative project between researchers at Teagasc Moorepark and the Agri-Food and Bioscience Institute in Northern Ireland has been looking at slaughter management and optimal grouping strategies for entire male pigs.

It is advantageous for the welfare of young male piglets that they are not castrated. However, the trend towards higher slaughter weights means that entire male pigs are sexually mature at the end of the finishing period. The intense aggressive and sexual behaviours they perform give rise to a different set of welfare problems, including stress and injury. These behaviours are also associated with the production of androstenone, a steroid hormone, and one of two main compounds responsible for boar taint. This is an offensive smell and taste that emanates from the meat of entire male pigs when it is cooked. The fact that male piglets are not castrated gives the Irish pig industry an important welfare advantage over its European competitors. However, this advantage can only be exploited in our export markets if the problems of boar taint and welfare issues for entire male pigs are addressed.

Table 1: Effect of live weight at slaughter on skatole and androstenone levels in the backfat of entire male pigs.

Live-weight at slaughter (kg)	Compound	
	Skatole (ppm)	Androstenone (ppm)
80	0.16	0.61
100	0.33	1.04
120	0.18	1.14



Slaughter management

In a study to define optimum slaughter weights pigs were slaughtered at 80, 100 and 120kg and levels of boar taint compounds were determined in samples of backfat from the males. Unsurprisingly, skatole, the second of the two main boar taint compounds, showed no clear relationship with slaughter weight (**Table 1**) as it is unrelated to sexual maturity. Indeed, skatole is easily controlled by feeding and keeping the pigs clean. However, androstenone, which is genetically determined and therefore more difficult to control, increased with slaughter weight. Androstenone was above the cut-off level for detection by a trained sensory panel (0.5-1mg/kg) at each of the weight categories examined, indicating that reducing slaughter weights will not address the problem of boar taint. There are two options for marketing pigs. The first involves selling all the pigs in a pen together so that they are the same age and the risk of boar taint is reduced. The downside for producers is that the risk of incurring penalties imposed by the slaughter plants for pigs outside the desirable weight range is increased, as sale weights will vary greatly. The second option is to split market, which is to slaughter the heaviest pigs in a pen one to two weeks early to allow lighter pigs to reach the required weight. This reduces the risk of penalties but means that the slower growing pigs are considerably older at slaughter. Furthermore, split marketing disrupts the dominance hierarchy, which could ignite aggression among entire male pigs as they have a less stable social order than females. In an initial study, skin lesion scores (indirect indicator of aggression) tended to be higher in groups of entire males that were split marketed (Boyle and

Bjorklund, 2007), suggesting that, in line with our hypothesis, the remaining males fought to re-establish the dominance hierarchy. Results from more recent work reveals that fights in split marketed groups last significantly longer (0.41% vs. 0.17% of the observational time) and confirms that this increase is related to the male groups. Boar taint data from this work has not yet been analysed.

Grouping strategies

Gender composition

When considering grouping strategies for entire male pigs the question arises as to whether it is better to keep them in single or mixed sex groups. Young male free-living pigs live in bachelor groups, suggesting that single sex groups are more 'natural'. However, in contrast to most bachelor groups where the libido of individual males is suppressed, young male pigs stimulate each other to sexual maturity. This is why free-living boars eventually disperse and lead a solitary life. Owing to the causal relationship between sexual maturity and the production of testosterone, it is not surprising that levels of aggression seen in single sex groups of males are much higher than those seen among females (Boyle and Bjorklund, 2007). When the sexes are mixed together levels of aggression are similar to those seen in the females. This represents an important welfare benefit of mixed sex groups for male pigs. However, mounting behaviour is performed to the same extent in mixed sex groups as in all-male groups. This suggests that it is unlikely that we will detect a beneficial effect of mixed sex grouping on boar taint. There are suggestions that, instead of mixing male and female pigs together in the same group, they should be kept in separate groups but given good visual and olfactory contact. Research from the UK has shown that this not only reduces aggression among the males but also reduces mounting and fat androstenone and skatole concentrations.

Weight variation

On pig farms, considerable effort is devoted to creating uniform groups at regrouping. This is in the belief that uniform grouping results in less social stress within the pen and reduces weight variation at marketing. However, weight variation at marketing is similar in groups that were either uniform or heterogeneous when grouped together at the beginning of the grower phase. Furthermore, there may be less aggression within heterogeneous pens following regrouping because pigs do not need to fight to establish a dominance hierarchy when clear differentiation by weight is possible. Initial results from a recent study support this hypothesis, with the highest skin lesion scores seen in single sex groups of males where the variation in weight was low (i.e., uniform) and the lowest scores being seen in high variation or heterogeneous mixed sex groups (Figure 1). Pen weight variation had no implications for mounting behaviour in either the single or mixed sex groups. It remains to be seen from further analysis whether this strategy will reduce the boar taint compounds but it is likely that heterogeneous groups could play a role in addressing the problem of aggression between entire male pigs.

Implications for industry and future work

Consumers in many of Ireland's export markets for pig meat are thought to be more sensitive to boar taint than consumers in Ireland and the UK. This is because they traditionally eat pork exclusively from castrated males while we are accustomed to eating pork from entire male pigs. Hence boar taint poses a huge risk to the reputation of the Irish pig industry and, ultimately, to market share

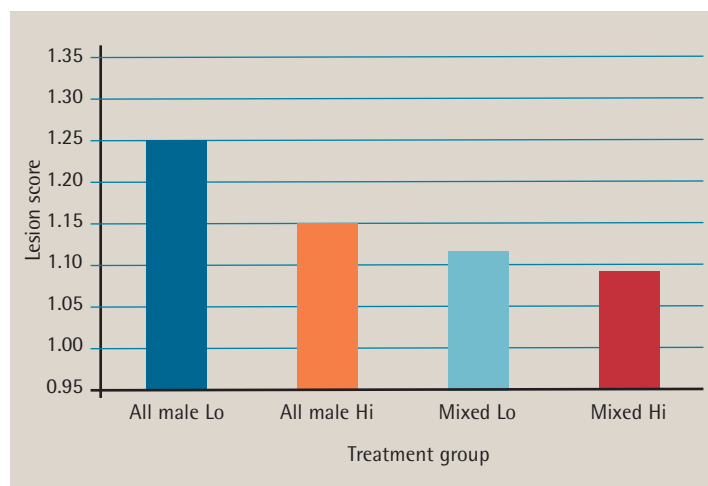


FIGURE 1: Effect of pen weight variation (high or low) and gender (male or mixed sex) composition on skin lesion scores of finishing pigs.

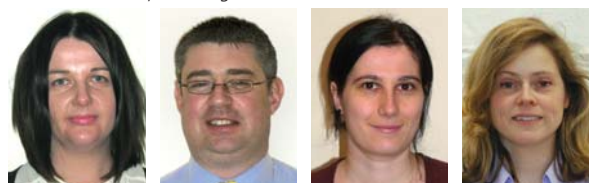
abroad. Reducing the slaughter weights of male pigs is inadequate to address the problem. Surgical castration will not be re-introduced to Ireland as even with modern genotypes, boars still grow more efficiently, making them more profitable to rear than castrates. In any case, castration of young pigs is controversial and is soon likely to be limited in the EU to circumstances where analgesics and/or anaesthetics are employed. Management and housing strategies offer real potential to address the welfare problems associated with rearing entire male pigs but it is unclear if they will also reduce boar taint. Immunocastration offers the most promising solution for the future as it addresses the problems of boar taint, aggression and sexual behaviour without the need for painful surgery. However, there are doubts as to whether the practice will be acceptable to consumers in the EU.

This research is funded by the Teagasc Core Programme.

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Over-wintering options for weanling heifers

EMER KENNEDY, Teagasc Moorepark, has been looking at the use of forage brassicas as an alternative over-winter feed source.



Milk quotas are due to be abolished by April 2015 exposing future milk price to substantial fluctuation over the next number of years. Yet Ireland has a competitive advantage over other EU milk-producing nations because of its potential to grow 12 to 16 tonnes of dry matter per hectare (t DM/ha) of pasture, over a long growing season of up to 11 months. Increased utilisation of pasture through increased stocking rates is the main avenue to increase productivity and profitability on Irish dairy farms. Thus, it is envisaged that herd sizes will increase substantially over the coming years, particularly after the abolition of quotas. However, larger herd sizes mean that a greater number of replacement heifers will need to be reared and catered for. In 2008, incomes on specialist dairy farms declined by 10% to €45,732 per farm, due mainly to an increase in direct and overhead production costs. Given this reduction, there is less free capital available for the construction of new infrastructure to house replacement heifers during the winter period; therefore, alternative options need to be considered.

As pasture systems of production predominate in Ireland the natural assumption would be to gravitate towards maintaining animals outdoors all year round. Grazing animals on perennial ryegrass throughout the winter months is commonplace in New Zealand where the climate is conducive to year-round growth. In Ireland, there is very limited grass growth over the winter months;

thus grass that is to be grazed *in situ* during this time needs to be accumulated from autumn onwards. However, the utilisation of herbage during the winter months may be curtailed due to the susceptibility of land to poaching, associated with rainfall and soil type. Further limitations to over-winter grazing are increased proportions of dead material due to leaf senescence, consequently reducing dry matter (DM) digestibility and the crude protein (CP) concentration in herbage. A recent experiment conducted at Moorepark found that non-lactating dairy cows offered deferred grass during the winter months did not have sufficient DM or energy intakes for maintenance and gestation, and were found to be below the recommended body condition score (BCS) at calving, indicating that higher quality feeds need to be offered over the winter months.

Forages as alternative winter feed

Although grazed grass is the cheapest feed available, forage brassicas such as kale are only 1.5 times more expensive than grazed grass. This is considerably cheaper than other feed sources, such as grass silage and concentrates, which are 2.3 and 3.6 times more expensive than grazed grass, respectively. Thus, forage brassicas offer farmers a real alternative: they grow at lower temperatures (<6°C) than perennial ryegrass; produce dry matter (DM) yields of up to 15t DM/ha within five to six months of sowing; and, maintain high energy values (1.03-1.12

Table 1: Chemical composition of the silage offered.

	DM (%)	DMD (%)	pH	Ash (g/kg)	NDF (%)
Good quality silage	22.6	72.0	3.87	19.2	11.6
Poor quality silage	26.0	59.9	4.55	24.1	14.3
Bale silage	33.5	65.5	4.75	29.7	16.7

DM = dry matter; DMD = dry matter digestibility; NDF = neutral detergent fibre.

Unité Fourragère Lait [UFL] per kg DM) over the winter. Forage brassicas, however, have a low neutral-detergent fibre (NDF) concentration (<300g/kg DM) in addition to a high DM digestibility (>0.800), suggesting that feeds with a higher NDF concentration (>500g/kg DM) may need to be offered in order to avoid acidosis. However, feeding a fibre source such as silage increases the labour associated with forage crops and also increases total feed costs. A recent short-term (20-day) indoor feeding experiment examined the effect of feeding a 100% kale diet in comparison to varying combinations of a kale and silage diet. The results of the experiment reported that feeding a 100% kale diet did not reduce rumen pH below 6.0, nor did it induce acidosis.

Over-winter experiment

Given the positive indicators from this study, a large scale *in situ* grazing experiment was undertaken from mid-November to mid-February (90 days) last year at Moorepark. One hundred and twenty weanling heifers were divided into four equal groups on the basis of breed, age, live weight, BCS and sire. The four treatments were:

- 100% kale (100K);
- 70% kale + 30% grass silage (70K);
- Good quality silage (>70% DMD [dry matter digestibility]; GS); and,
- Poor quality silage (<70% DMD; PS).

All heifers were offered *ad libitum* access to each of their respective offered feeds. The quality of the three silages offered is presented in **Table 1**. Over the experimental period the DM intakes of the heifers assigned to the 100K, 70K and PS treatments were approximately 5.8kg DM/heifer/day. However, the DM intake of the GS heifers was only 4.8kg/heifer/day. Although the silage offered to the GS heifers had a higher digestibility than the PS, the DM of the PS was over 3% greater, which resulted in higher intakes being achieved by the PS heifers over the experimental period. Thus, there was no difference in over-winter live-weight gain between heifers assigned to the GS and PS treatments (0.30kg/day; **Figure 1**).

The two groups of heifers that were wintered outdoors had a higher live-weight gain during the experimental period (November to February) than the GS and PS treatments that were wintered indoors. However, the 70K heifers had a higher daily live-weight gain (0.49kg/heifer/day) than the 100K heifers (0.41kg/heifer/day) during the experimental period. The BCS of the 70K and 100K heifers was also greater than that of the GS and PS heifers after the winter period.

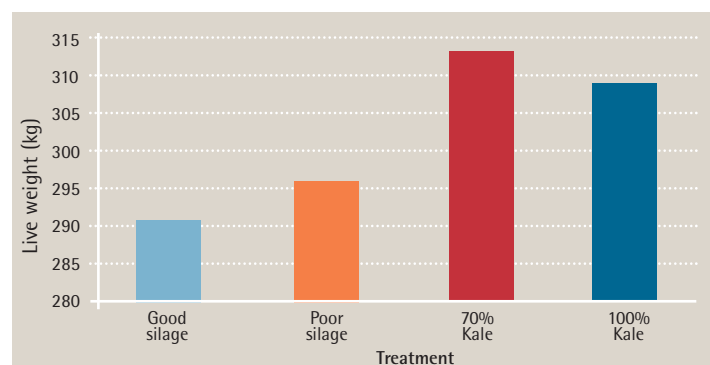


FIGURE 1: Effect of over-winter feeding treatment on heifer weight at the start of the breeding season (April 16, 2009).

Target body weights

Achieving target body weights is an integral part of every heifer rearing system. One of the key target weights that should be achieved coincides with mating start date. Previous research has indicated that heifers should be mated at 55-60% of mature live weight and should calve at 85-90% of mature live weight. The target weight that Holstein-Friesian heifers need to achieve at mating start date is 330kg, while Jersey crossbreds should weigh 295kg, which demonstrates a large difference in target weights between breeds. Evidently from **Figure 1** the average weight of predominantly Holstein-Friesian heifers from each of the four groups was below target. However, it is also apparent that the 70K and 100K heifers were significantly heavier (311kg) than the GS and PS heifers (294kg) at mating start date (April 16). This difference in live weight remained for the rest of the year – on September 15, the GS and PS heifers weighed 435kg while the 70K and 100K heifers weighed 454kg – there was no difference in BCS. This difference in live weight was reflected in the superior fertility performance of the heifers over-wintered outdoors on kale as a greater proportion of these animals are pregnant and are also calving, on average, seven days earlier than the GS and PS heifers.

Benefits to industry and further work

The results from the study indicate that there were no ill effects of offering a 100% kale diet for a 90-day period on the live-weight gain, BCS or fertility performance of heifers. Yet adopting this system would result in lower feed and labour costs because of the elimination of grass silage bales from the diet. The experiment is currently being repeated to ensure that similar results are achieved over two years, and also to compare a kale diet to a more conventional system of grass silage and concentrate offered indoors.

This research was funded by Teagasc Core Funding.



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Rumen pH in grazing dairy cows

The study of rumen pH is important, as low rumen pH is a factor implicated in the development of low milk fat, lameness and laminitis, and reduced intake and digestibility of feed. Much of the work into low rumen pH in dairy cows has focused on high concentrate systems unlike the grass-based systems with which we are familiar. A recent study at Moorepark has been looking into rumen pH on typical Irish grass-based diets.

We can't see rumen pH; nevertheless, it is an important component of the nutritional processes of a dairy cow. Low rumen pH can be linked to problems such as low milk fat, lameness and laminitis, and reduced intake and digestibility of feed. These we can see! And they can all pose serious problems to the welfare of the cow and to the economic profitability of the dairy farmer and the dairy industry as a whole.

What is happening in the rumen?

A dairy cow, like all ruminants, has four stomachs. The largest of these is the rumen, which acts like a fermentation vat. Here, the feed taken in by the cow is broken down by the action of the large population of microorganisms that reside in the rumen. These microorganisms are made up of bacteria, fungi and protozoa and operate in the absence of oxygen, otherwise known as 'anaerobic conditions'. Different microorganisms have different jobs. For example, some can digest cellulose and hemi-cellulose and are referred to as fibre-digesters, while others can digest starch and are referred to as starch-digesters. The number and type of microorganisms in the rumen is related in part to the type of feedstuffs offered to the cow. As a result, the microorganism population of the rumen will change depending on the type of feed offered to the cow.

The microorganisms work to break down the feed ingested by the cow. In this way carbohydrates are broken down to volatile fatty acids (VFAs). The VFAs are then absorbed through the rumen wall into the bloodstream and are the main source of energy for the cow. If there is a difference in the net appearance of



VFAs (VFAs produced–VFAs absorbed), then there can be a build-up or accumulation of acids in the rumen. This causes the pH in the rumen to fall. If the rumen pH falls too low, then the negative consequences mentioned above may be seen, i.e., milk fat depression, feet problems and impaired absorption of nutrients. This is often referred to as sub-acute ruminal acidosis, or SARA.

Definition of SARA

Most of the work on rumen pH, and SARA in particular, has taken place using high-producing dairy cows offered high concentrate diets. Although there is much debate as to what a 'normal' rumen pH is, and under which rumen pH point SARA is said to be present, broadly speaking a cut-off point of rumen pH 5.5 to 5.8 is used. Thus, cows with a rumen pH above this level are classified as being normal, while those with a rumen pH below this point are classed as suffering from SARA. However, most of the research carried out on low rumen pH or SARA has been on high concentrate diets and, in this scenario, SARA has been associated with fluctuating dry matter intake, reduced milk fat and reduced feed digestibility, in particular fibre digestibility.

Unfortunately, much less work has been conducted on rumen pH utilising the type of pasture-based systems with which we are familiar in Ireland. It could be expected that high quality pasture – similar to that being offered to Irish dairy cows at different stages of lactation – would give rise to low rumen pH, as pasture is characterised by high energy density, high rapidly fermentable carbohydrate (water-soluble carbohydrate) and low structural carbohydrate



levels. Despite this, it has been suggested that cow performance on high quality pasture may not be compromised by low ruminal pH to the same extent as when cows offered high concentrate diets suffer low rumen pH.

Work at Moorepark

This agrees with some work conducted recently in Moorepark. In 2009, the equipment necessary to measure rumen pH on a continuous basis was purchased, modified, developed and utilised. A series of studies was run, which looked at the rumen pH of lactating dairy cows offered a range of different diets. The objectives of the studies were to set up and validate a system for the measurement of rumen pH on a continuous basis and to compare the rumen pH of dairy cows offered different diets.

One study compared the performance and rumen pH of dairy cows offered a pasture or total mixed ration (TMR) diet in the late spring–early summer. The cows offered the pasture diet were grazing full-time, were offered 17kg grass (DM/cow/day) and were grazed to a post-grazing sward height of 4cm. The cows offered the TMR diet were housed indoors and offered a TMR composed of maize silage, grass silage, straw and concentrate for *ad libitum* intake. As expected, intake and milk yield were greater on the TMR diet. The milk protein concentration of the pasture-fed cows was higher than that of the TMR-fed cows. However, milk fat concentration, a key indicator of SARA, was not affected by treatment. In addition, no treatment effects on lameness (another SARA indicator) were recorded in the cows over the duration of the study.

A small subset of the cows in the study were utilised for rumen pH monitoring. These cows were offered one diet for five weeks and then switched to the other diet for five weeks. The rumen pH of each cow on each diet was recorded for 48 hours. The average rumen pH of the pasture cows was 5.84 and of the TMR cows was 6.06. The pasture cows spent 40% of the day under rumen pH 5.8 compared to the TMR cows spending 10% of the day, while no statistically significant difference was found. It is interesting to note, however, that despite the low rumen pH values exhibited by the pasture-fed cows, no negative effects on performance or welfare were measured. This agrees with the hypothesis put forward by New Zealand researchers that cow performance on high quality pasture may not be compromised by low ruminal pH to the same extent as when cows are offered conserved forage and high concentrate levels. The reason for this may lie in the production of lactic acid. Pasture contains no starch, and the low rumen pH levels seen from pasture diets results from intensive VFA production. However, grain-based diets contain high levels of starch, which encourage the propagation of starch-digesting microorganisms, some of which produce lactic acid. Thus, the low rumen pH seen on these diets is due to VFA plus lactic acid production. Lactic acid is 10 times stronger than the VFA (acetic, propionic, butyric acid) and it is lactic acid that causes reduced fibre digestion by inhibiting the action of the fibre-digesting microorganisms.

Benefits to industry and future studies

In Moorepark during the study described above, rumen fluid samples were taken from the cows while rumen pH was being recorded. These samples will now be analysed for the different VFAs and for lactic acid, in order to identify if dairy cows grazing pasture do indeed produce high levels of VFAs, without the concomitant increase in lactic acid production. The samples will also be analysed for the predominant microorganism species present.

In addition, the study above was part of a larger environmental greenhouse gas project. Methane is produced in the rumen by the normal digestive processes, but is a potent greenhouse gas. There are important associations between methane production and the pH, VFA concentrations and microorganism species present in the rumen. Thus, the analysis of these parameters will be important in understanding and manipulating methane production by dairy cows at pasture. The study of rumen pH is important in order to avoid dairy cow production performance and welfare problems. As a result, research in this area is continuing, with a particular focus now on those scenarios that are postulated to give rise to rumen pH problems, such as highly digestible grass and clover swards, and the early spring period of the year.

Acknowledgements

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Reducing methane emissions from cattle

Teagasc Animal Production and Grassland Research Centres in Grange and Moorepark are collaborating with University College Dublin, the Department of Agriculture, Fisheries and Food, and the AgriFood and Biosciences Institute of Northern Ireland in a multi-pronged approach to reducing methane emissions from cattle.

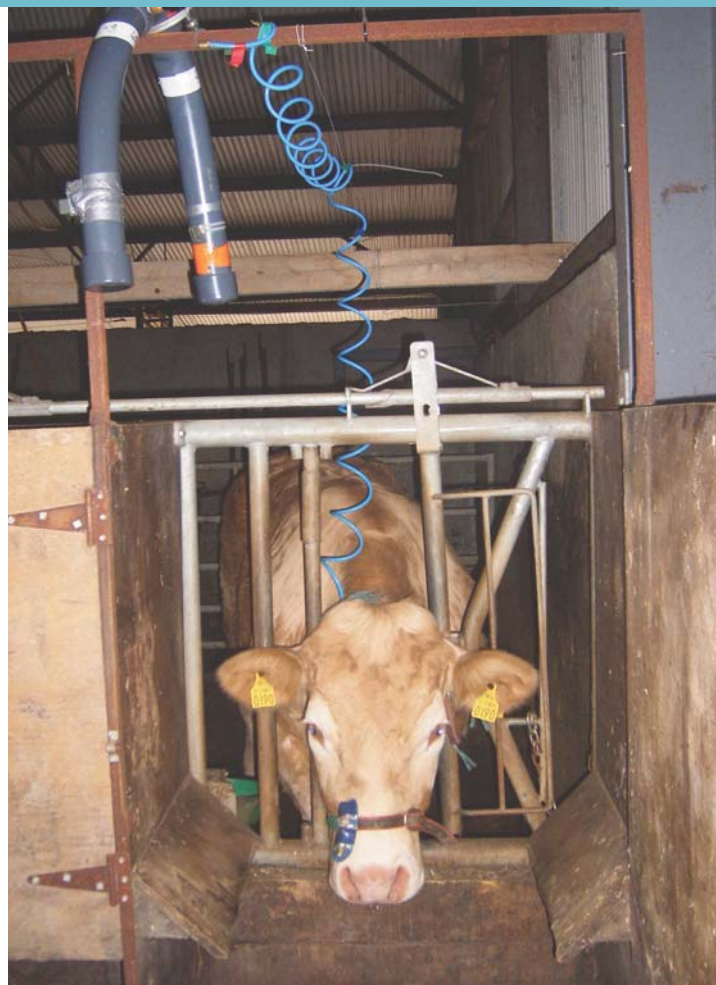
Greenhouse gas effect

Much of the solar energy absorbed by the earth is radiated back into the atmosphere as infrared heat. This would quickly be lost to outer space and the mean temperature of Earth would be some 30°C lower than at present were it not for the insulating effect of both clouds (water droplets) and greenhouse gases (GHGs).

The main GHGs are water vapour (H₂O), carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), fluorinated compounds and ozone (O₃). When molecules of these gases absorb infrared radiation they vibrate and emit radiation, and this radiant energy will likely be absorbed by an adjacent GHG molecule. This absorption-emission-absorption cycle helps to keep heat energy near the earth's surface. In contrast, nitrogen (N₂) and oxygen (O₂), which between them account for 99% of air, are too tightly bound together to vibrate in this way and thus they do not absorb infrared energy and are not GHGs.

Global warming potential

Besides individual anthropogenic GHGs differing in the 'efficiency' with which they 'trap heat' in the atmosphere, they also differ in how long they endure. CH₄ has a radiative efficiency of $3.7 \times 10^{-4} \text{ W m}^{-2} \text{ ppb}^{-1}$ and a standard lifetime in the earth's atmosphere of 12 years, while N₂O has corresponding values of $3.03 \times 10^{-3} \text{ W m}^{-2} \text{ ppb}^{-1}$ and 114 years. The global warming potential (GWP) of a GHG is an index of its ability to absorb and emit infrared radiation (and therefore act as a GHG) adjusted for its standard lifetime, and is expressed relative to CO₂. Values are typically expressed for a 100-year horizon, and CH₄ and N₂O have GWP values of 25 and 298 carbon dioxide equivalents, respectively. This means that over a 100-year horizon, 1kg of CH₄ has 25 times the global warming effect of 1kg of CO₂.



Measuring methane emissions from cattle.

National emissions

Internationally agreed and binding limits (e.g., the Kyoto Protocol and EU-2020) restrict the amount of GHGs Ireland can emit. Current official calculations indicate that agriculture accounts for 27% of our total national emissions and that CH₄ produced by the digestive system of livestock contributes half of the output coming from agriculture. Most of this enteric CH₄ is produced by beef and dairy cattle, for which it represents a 2-12% loss of the gross energy ingested.

Rumen

Ruminants are unique in the extent to which they access the energy in fibrous feeds. This access reflects the symbiotic relationship with bacteria, protozoa and fungi in their rumen. Much of this energy is released by microbial digestion as fermentation acids. A by-product of this process is the production of metabolic hydrogen, the amount of which must be kept very low in the rumen if fibre digestion is to continue efficiently. CH₄-producing bacteria (methanogenic Archaea) facilitate this process within the mixed microbial ecosystem in the rumen – they derive their energy for growth and multiplication from being able to combine hydrogen with CO₂ to produce CH₄. The availability of hydrogen depends on the particular fermentation acids produced by rumen microbes – processes yielding acetic (typically 60-70% of fermentation acids) and butyric (5-15%) acids release hydrogen and thus facilitate methanogenesis, while the formation of propionic acid (15-20%) utilises hydrogen and thus competes with methanogens, thereby reducing methanogenesis. Some of these methanogens exist in symbiosis with protozoa, often being found within or adhering to the surface of protozoal cells.

Rumen CH₄ is mainly disposed of by eructation (the gas is passed up the oesophagus and into the lungs before being exhaled) but a small proportion is

absorbed into the blood and expired through the lungs. Whereas most enteric CH₄ originates in the rumen, hindgut fermentation can account for 6–14% of daily CH₄ production. Most of the latter is also absorbed and excreted via the lungs but a small amount exits through the anus.

Mitigating enteric methane

A reduction in enteric CH₄ emissions from the existing population of ruminants will require a combination of strategies for reducing methanogenesis and improving animal productivity. Ultimately, however, in order to properly assess the value of any particular mitigation approach, it is essential that it is evaluated in terms of its overall GHG effect – this means that a full life-cycle analysis would be undertaken to account for all direct and indirect GHG fluxes up to the point where animal product is sold from a farm.

1. Reduce methanogenesis

- (a) **Animal genetics:** Considerable variability exists between animals in enteric CH₄ output, and selecting breeding animals for lower methanogenesis could provide valuable reductions in CH₄ output for traits that are heritable. These effects could be mediated through intrinsic differences between animals in their enteric microbial ecosystem or characteristics such as retention time of feed particles in the rumen.
- (b) **Feed ingredients and management:** Increasing feed intake and/or digestibility, although it can increase daily CH₄ output per animal, will usually reduce it per unit feed intake. Higher intakes or digestibility reduce residence time for feed in the rumen and this conflicts with the dynamics of methanogens, and favours propionic acid production and a lower pH. The latter is hostile to protozoa, with which methanogens associate closely. Practices that favour these outcomes include ensuring that animals have *ad libitum* access to feed (grazed or conserved), grazing and ensiling leafy herbage rather than herbage with a high content of stem or dead material, grinding or alkali treatment of low digestibility forage, etc. Changing the type of carbohydrate consumed by ruminants alters the proportions of fermentation acids and the pH in the rumen contents. Generally, CH₄ per kg intake is lower with starch, intermediate with sugar and higher with fibre. Practices that favour these outcomes include using leafy grass, combining grass with clover, using high sugar grasses, increasing the grain content of the diet (including strategic supplementation with concentrates), using silage rather than hay, etc.
- (c) **Newer technologies:** There are various minor ingredients that have the potential to reduce CH₄ output when included in the diet. In each case it is necessary that the ingredients do not have negative side effects and that their effects persist for as long as they are fed. Thus, a range of methanogen inhibitors (e.g., 2-bromoethanesulfonic acid, tannins), ionophores (e.g., monensin), propionate enhancers (e.g., fumarate, malate), probiotics (e.g., *Saccharomyces cerevisiae*), defaunation agents (e.g., saponins) and fats (C8–C14 fatty acids, particularly when unsaturated) have been assessed. For example, coconut oil reduced enteric CH₄ output by defaunation, favouring propionate production and providing an alternative hydrogen sink via bio-hydrogenation. Immunising ruminants against their own methanogens is an interesting concept. The highly diverse methanogenic community in the rumen presents a difficult challenge, but genomic information may permit development of

more targeted vaccines. Exploratory research is ongoing with bacteriocins against hydrogen-producing microbes, with archaeal viruses and with selecting acetogenic bacteria from the hindgut (where they use hydrogen to reduce CO₂ to acetic acid) that might impact in the rumen. The prospects of adapting CH₄-oxidising bacteria to mitigate rumen methanogenesis seem negligible.

2. Improve animal productivity

Practices that increase the efficiency with which ruminants produce meat, milk or progeny reduce CH₄ output per unit product. The result is that fewer 'CH₄-producing' animals are required to produce a given amount of product or that animals need only produce enteric CH₄ for a shorter duration. Examples of factors influencing this include:

- (a) **Animal genetics:** Selecting high genetic merit animals that are more efficient at converting feed to meat or milk, that have greater reproductive longevity, etc., increases the amount of animal product sold per unit enteric CH₄ emitted.
- (b) **Animal management:** Practices that optimise the fertility of breeding animals or that greatly limit ill health will improve productivity.
- (c) **Animal nutrition:** Ensuring that ruminants have *ad libitum* access to a high quality, nutritionally balanced diet promotes high performance and thus increases the amount of animal product sold per unit enteric CH₄ produced.
- (d) **Performance stimulants:** these have a similar effect to improved nutrition, but some are not permitted in the EU.

Benefits to industry

To conform to internationally binding agreements Ireland must reduce its emissions of GHGs. The contribution by ruminant agriculture can come from a reduction in the GHG output per animal rather than from a reduction in animal numbers. Reducing the output of CH₄ from the digestive activities of ruminants will come from a combination of changes in farm practice rather than from adopting a single new technology. Farmers will be most likely to adopt those technologies that simultaneously enhance their profits.

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T Events

MARCH

March 2

Teagasc Ashtown Food Research Centre

2nd Symposium of the Irish Phytochemical Food Network

This symposium is part of a series of annual symposia focusing on phytochemicals from Irish grown fruits and vegetables in a farm to fork approach. The main aim is to provide an update on phytochemical research and its impact on human health from an Irish context.

This year Professor Elizabeth H. Jeffery from the University of Illinois is keynote speaker. Her team has been working on developing a "better broccoli" that will decrease the risk of cancer without greatly changing people's dietary habits. The event is free access (but registration is necessary) and anyone from the food industry is welcome, from growers, producers and processors of fruits and vegetables to researchers, community groups and health professionals.

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<http://www.teagasc.ie/ashtown/events/2010/201002-09.asp>

March 9-11

Silver Springs Moran Hotel and Conference Centre, Cork

US/Ireland Functional Foods Conference:

Dietary Optimisation of Gut Function and the Microbiota

Functional foods are identified as one of the central pillars for the future development of the food industry internationally. In a recent foresight exercise undertaken by Teagasc, research in functional foods is seen as a priority to support the ambitions of Irish industry to compete in this market segment. In connection with this aim, Teagasc, University College Cork and the USDA have combined to organise US/Ireland Functional Foods Conference 2009, to bring together leading scientists whose research is important for the realisation of these ambitions.

This conference will focus on the science of gut function and response to diet and will address gut hormones and incretin release, gut microbiota for optimal gut function, and biomarkers for enhanced health through diet. While the health effects are broad, they will naturally be those that are diet-related and that connect to gut responses linked to such conditions as obesity and the metabolic syndrome. The conference will focus on the sciences that the food industry will need to develop functional foods and bioactives with validated health claims.

Scientific programme: catherine.stanton@teagasc.ie;

Registration: louise@conferencepartners.ie

www.corkff2010.com

March 22

Teagasc Ashtown Food Research Centre

Food law update

This one-day seminar, presented by Leatherhead Food Research, will cover new and proposed Irish and EC legislation of interest to the food and related industries.

margaret.hennessy@teagasc.ie

Tel: 01 805 9520

www.teagasc.ie/ashtown/training/

March 23

Ballydague, Co Cork

Dairy research farm walk

padraig.french@teagasc.ie or brendan.horan@teagasc.ie

APRIL

April 12-14

Queen's University, Belfast

Agricultural Research Forum and British Society for Animal Science joint meeting

This joint meeting will have sessions on soils and the environment, crop science, grassland and agricultural economics in addition to regular sessions on animal science. A number of leading international scientists have been invited to present plenary papers on topics of current interest and importance across all of the above disciplines.

The overall theme for the Conference is 'Food, Feed, Energy and Fibre from Land – A Vision for 2020'.

World food demand is predicted to double from present levels by 2050, driven by a projected 40% increase in population growth and changes in eating patterns. This will undoubtedly lead to greater demand for livestock products. However, our ability to increase food production is constrained by a number of factors, including competing demands for land use for energy production and recreational use, together with the impact of climate change on land availability and productivity. This conference will bring together a range of international research scientists to discuss future priorities for agricultural research and development and, in particular, to examine factors influencing the efficiency of food and energy production. Major themes for the conference will include: food production, energy from land; implications for land use; and knowledge and innovation transfer and interaction.

www.bsas.org.uk/Meetings_&_Workshops/

April 27

Teagasc Ashtown Food Research Centre

Ideas and inspiration in food and drink products

This course will inspire delegates to use very simple but highly effective tools and techniques to run idea-generating sessions, and give them the ability, confidence and techniques to 'pick winners', whether idea, product, or process. Participants will master the evolutionary technique of cube crawling as a tool for idea generation.

margaret.hennessy@teagasc.ie

Tel: 01 805 9520

www.teagasc.ie/ashtown/training/

MAY

May 6

Ballyhaise College, Co Cavan

Dairy research farm walk

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JUNE

June 24-25

Dublin, venue TBC

Low-carbon food: Opportunities for leading in carbon-efficient agricultural production

Can we reduce the carbon footprint of farming while meeting an increasing global demand for food? How can we further raise carbon efficiencies in temperate agriculture and can we account for these improvements in the existing greenhouse gas (GHG) inventories? Are these developments helped or hindered by the Copenhagen agreement? Is Ireland positioned to become the global leader on low carbon footprint food?

These are the central questions of the second Teagasc Agri-Environmental Policy Conference Series. This conference aims to bring together national and international scientists, policy makers, and industry stakeholders to discuss the challenges and opportunities of reducing GHG emissions from agriculture.

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JULY

July 7-8

Teagasc Ashtown Food Research Centre

Legal labels Ireland – The essential guide to Irish food labelling

Legal Labels Ireland (presented by Leatherhead Food Research) is structured to function as a fully comprehensive review of current regulations and official recommendations. Presentations cover all major labelling considerations, including product-specific labelling for foods with compositional standards, nutrition and health claims, and new developments in general food labelling.

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www.teagasc.ie/ashtown/training/