

T Research

Research and innovation news at Teagasc

Herbivore hitchhikers



The science of soils
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Grazing in wet weather

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Science Week – encouraging young scientists

Once again, Teagasc is involved in Forfás' Science Week initiative, which runs from November 9 to 16. Science Week highlights the relevance of science, engineering and technology in our everyday lives. It demonstrates the importance of these disciplines to the future development of Irish society and the economy.

Science Week is co-ordinated by the Discover Science & Engineering (DSE) programme of Forfás. DSE aims to increase interest in science, technology, innovation and engineering among students, teachers and members of the public. Its overall objectives are to encourage more students to study the physical sciences, promote a positive attitude to careers in science, engineering and technology, and to foster a greater understanding of science and its value to Irish society.

Teagasc is fully involved in the initiative, organising events for second, third and fourth level students and the general public. Most importantly, and as befits the largest employer of research fellows working in the agriculture and food sector in Ireland, the annual Walsh Fellowship Seminar is the highlight of the week. Beyond the realm of Teagasc, Science Week is an essential tool in generating interest in science at an early age. It challenges us to communicate our work to a broad audience, addressing real issues that are tangible to all ages and interests.

Additionally, in these more stringent financial times, it is essential that funding continues to be available for science and research. Science, engineering and technology contribute to the Irish economy through the development of cutting-edge innovation and the provision of high skilled jobs.

It is up to all organisations in the 'business of science' to encourage the next generation. Collectively, we need to encourage enquiring minds and foster a culture of innovation that will play a central role in the development of a knowledge economy. Science Week has an important role to play in that process and Teagasc can play a committed role in Science Week.



Catriona Boyle
Editor

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Appointment – Professor Richard Dewhurst

Professor Richard Dewhurst recently joined Teagasc as an animal bioscientist at the Animal Bioscience Centre, based in Grange. Richard has most recently been Professor of Dairy Science at Lincoln University in New Zealand, and before that he was a research scientist at IGER in Aberystwyth, Wales. Richard will work in the area of animal nutrition in Teagasc.



His research interests to date include:

- biomarkers for increased feed efficiency and reduced environmental impact in ruminants;
- proteomics of the relationships between rumen protein transformations, feed intake and feed efficiency;
- fatty acid effects on gene expression for milk quality, immune competence and fertility; and,
- breath-based biomarkers of metabolic stress and rumen function.

Teagasc Authority appointments

The Minister for Agriculture, Fisheries and Food, Mr Brendan Smith, TD, has appointed Dr Noel Cawley (pictured right) as the new Chairman of Teagasc. Dr Cawley takes over from Dr Tom O'Dwyer, who has completed two five-year terms as Chairman. Dr Cawley was Chief Executive of the Irish Dairy Board until 2006. He also served as Chairman of the Irish Horse Board, and more recently chaired the Government-established Seafood Strategy



Review and Implementation Group. A native of Co. Sligo, Dr Cawley also served as Chairman of the Farmers' Charter Monitoring Group set up by the Department of Agriculture, Fisheries and Food, and is a Director of One 51 Plc. In addition to the appointment of a new chairman, Minister Brendan Smith has appointed two other new members to the Authority. Padraig Gibbons from Co Mayo will be the ICOS nominee on the board. He is a dairy farmer, Chairman of Connacht Gold co-op, and former president of ICOS. Frank O'Mahony from Co Cork has also been appointed for a five-year term. He was nominated by Macra Na Feirme.

Honour for service to agri-food industry

Dan Browne, one of the leading figures in the Irish meat industry, received a special award from the Agricultural Science Association (ASA) for his outstanding contribution to the profession of agriculture and to the agriculture and food industry over the past 50 years, at the Association's annual conference in Galway in September.

From a farming background in Douglas, Co. Cork, Dan Browne started his career as a research scientist. After graduating from UCD in 1959 with a degree in agricultural science, he joined the newly established agricultural research institute, An Foras Talúntais (now Teagasc).

His first posting was at the grassland research centre at Johnstown Castle in Wexford. In late 1959, he moved back to his native Cork and was given the task of developing a national dairy research centre on a derelict farm at Moorepark, outside Fermoy. He was the third scientist to be recruited to Moorepark and was central in building a world-class centre there over the following 15 years.

"The pioneering work of Dan Browne and his colleagues in Moorepark was vital in transforming dairy farming into the competitive and sophisticated business it is today. He not only developed the new science and technology, he also communicated it with enthusiasm and conviction to dairy farmers. His communications skills received national recognition, and in the early 1970s he presented a series of television programmes on dairying on RTÉ," said Elaine Farrell, ASA President.

In 1974 he left the world of research and joined the meat industry, becoming manager of the Cork Marts – IMP plant at Middleton. In 1980, he set up Dawn Meats with the Queally family in Waterford, and held the position of managing director of the company for the following 27 years.



From left: Gerry Scully, Teagasc, former President, ASA, with Michael Dowling, Head of Agri-Strategy, AIB (award sponsors), presenting Dan Browne with the award.

Under his leadership, Dawn quickly developed into one of Ireland's leading meat companies with plants in Ireland, the UK and France.

In tandem with his busy life as a leading meat industry executive, he also played an important part in the development of the farming and food industry. He was chairman of Teagasc from 1993 to 1998, a member of the board of An Bord Bia and, earlier this year, he was appointed chairman of Bord Bia. He is also a long-serving member of the Agricultural Trust, publisher of the *Irish Farmers Journal*.

Science Week



Science Week 2008 takes place from November 9 to 16, and Teagasc's Science Week committee has planned a range of events this year. Visits from local secondary schools will take place at the research centres in Ashtown, Athenry, Grange and Moorepark. Third-level students from Carlow IT will visit the research centre in Oak Park. Johnstown Castle Environment Research Centre will hold an international conference on 'Sustainable Grassland Systems in Europe and the EU Water Framework Directive', and Kildalton College will host a conference on animal nutrition. The annual Walsh Fellowships seminar will take place in the RDS on November 12. Dr Don Thornhill, Chairman, National Competitiveness Council, Forfás, is the guest speaker. The seminar will be followed by a lecture on 'The twin global insecurities: food and energy', given by Teagasc Director Professor Gerry Boyle as part of the RDS Speaker Series and under the auspices of the RDS Agriculture and Rural Affairs Committee, at 6.00pm (contact lectures@rds.ie to book a place).

Teagasc Gold Medal Award 2008



As part of Teagasc's AFT 50th anniversary celebrations, a Gold Medal is to be awarded to a serving staff member who is deemed to have made an outstanding contribution to the work of the organisation. Deadline for submissions is November 7 and the award will be made later in the year. This award will become an annual feature.

Older volunteers needed

Scientists from UCC, Cork area hospitals and Teagasc are looking for people to take part in a new project, which aims to improve digestive health in older people through a better understanding of intestinal bacteria.

The ELDERMET project is investigating the link between gut bacteria, food and health in the elderly in Ireland.

As people age, the beneficial properties of intestinal bacteria appear to weaken, and the immune system also slows down. Changes in these bacteria are linked to inflammatory disorders and even obesity. It is not yet clear which body defence functions and mechanisms are most dependent on gut bacteria, and this is what ELDERMET plans to find out. Controlling gut bacteria by changing the diet would then offer the chance to improve health – especially in older people.

ELDERMET is looking for volunteers over 65 who would like to take part in the study and help with establishing dietary strategies for the older Irish population. Interested individuals should contact Dr Siobhan Cusack, Tel: 021-4901754, E-mail: s.cusack@ucc.ie.

Green biorefinery conference

'German farmers are doing it for themselves', was the predominant theme presented at the 5th European Biorefinery Symposium in Flensburg, Germany. The conference focused on the concept of decentralised biogas and biorefinery plants, with farmers opting to form small co-operatives of between four to five members in order to establish these plants.

The type of anaerobic digesters or "biogas generators" that the co-operatives were able to build was dependent on two main factors, the capital available for investment, and government incentives (price paid per kW supplied to the grid). This in turn determined the type of biomass the co-operative members could supply, i.e., wet or dry biomass feedstock. The majority of farmers appeared to favour dry biogas production, as the German government pays more for biogas produced through dry fermentation processes. These digesters use feedstock such as grass or maize silage, whereas wet digesters include slurry in the feedstock. As part of the Symposium, delegates got to observe first hand these types of facilities in operation. As well as generating biogas from the grass and maize

silage, the residues remaining after the fermentation are also sold as fertiliser due to their high nitrogen content, therefore increasing the returns on such a venture. The main issues broached at the conference included the practical steps to be taken to introduce these biorefining technologies into farming communities, and the fundamental need to provide the right policy support systems in order to make biorefinery a sustainable future for farmers. These issues are also relevant for the future of Ireland's agricultural communities, particularly with the current instability of oil prices. The ability of a country to produce its own commodities, such as energy or plastics, from an alternative source other than oil is fundamental.

Research is currently being undertaken at Johnstown Castle by Walsh Fellow Sinead O Keeffe under the supervision of Rogier Schulte and Paul Struik (Wageningen University) investigating whether "green biorefinery", or using grass to generate various products such as biogas, is a viable alternative option for farmers.

Researcher profile

Professor Bryan Griffiths



Professor Bryan Griffiths is a Science Foundation Ireland-funded Stokes Professor in Soil Science, based at Johnstown Castle Environment Research Centre. A key aim of the position is to integrate soil biology more fully within the environment programme at Johnstown Castle, in particular to develop the molecular and microbiological capacities for analysing the detailed processes occurring within the soil. Professor Griffiths' initial projects aim to develop a molecular means of characterising soil nematode communities and to understand what factors ensure that soils are resilient to environmental stresses.

Professor Griffiths obtained a BSc in Applied Biology from Liverpool Polytechnic in 1979, and a PhD from Dundee University/SCRI in 1982 on the host plant response to feeding by the nematodes *Xiphinema diversicaudatum* and *Longidorus elongatus*.

In 1983, he took up the post of Higher Scientific Officer at the Department of Microbiology, Macaulay Institute for Soil Research, Aberdeen. He moved to the Zoology Department of the Scottish Crop Research Institute in Dundee in 1987 to work as Higher Scientific Officer, and held a variety of roles there, eventually becoming Associate Programme Leader, Environment Plant Interactions Programme, Leader, Plant Soil Interactions Research, in 2007.

Professor Griffiths' research grant awards include Principal Investigator on a Royal Society International Joint Project with Nanjing Agricultural University, to study 'Genetic control of lateral root growth stimulated by rhizosphere nematodes'. He is currently Principal Investigator on two Walsh Fellowship projects: 'Biodiversity and soil food web activity in differently managed grasslands', and 'Linking biological and physical resilience in Irish soils'. He is a member of the organising committee for the British Soil Science Society/Soil Science Society of Ireland (BSSS/SSSI) autumn meeting 2009.

Professor Griffiths also served on the evaluation panel for European Commission FP7-KBBE-2007-2B, Activity 2.1 in April 2008.

He has been a member of the editorial board of *Pedobiologia* since 1999, and of *Applied Soil Ecology* since November 2004.

He is a member of the British Society of Soil Science, the International Soil Science Society, the British Section of the Society of Protozoologists, the European Society of Nematologists and the Association of Applied Biologists. Professor Griffiths has published 131 peer reviewed papers and 25 book chapters and journal articles.

Agricultural Research Forum 2009 – call for papers

The 2009 meeting of the Agricultural Research Forum will take place in the Tullamore Court Hotel on March 12 and 13, 2009. Papers should be submitted to michael.diskin@teagasc.ie. For details of submission requirements, see www.agresearchforum.com.

The Investigators



Dan Milbourne, Oak Park Crops Research Centre, being interviewed for the new series.

Following on from the success of last year's television series *The Investigators* on RTÉ 1, Teagasc is co-sponsoring a second series of the show this year. The show is produced by New Decade TV and Film and will be aired on Thursdays on RTÉ 1 from November 6.

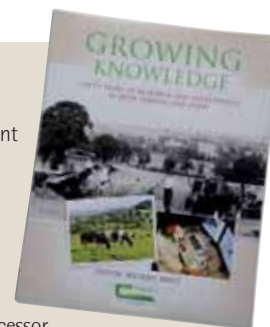
Teagasc researchers Dan Milbourne and Denis Griffin, Oak Park Crops Research Centre; Nigel Brunton and Eimear Gallagher, Ashtown Food Research Centre; and, Matthew McCabe, Grange Animal Biosciences Centre, will feature in an episode on 'Crops of the Future' on November 13.

Growing knowledge

Teagasc has published *Growing Knowledge*, a significant new book marking half a century of research and development in Irish farming and food. The book was launched by Brendan Smith, TD, Minister for Agriculture, Fisheries and Food, in September.

As part of Teagasc's AFT 50th celebrations, the book catalogues the achievements of Teagasc and its predecessor An Foras Talúntais since its foundation in 1958. Outlining the enormous input of science and innovation in agriculture and food, the book charts the events, politics and personalities behind the foundation of AFT and the central part played by United States funding under the Marshall Plan. It also marks the contribution of the advisory and education services to the improvements in Irish farming, food, forestry and horticulture.

Teagasc Director, Professor Gerry Boyle, said: "This book is an important record of the changes in agriculture and food over the period through a myriad of policy changes and economic developments. The 50 years of research has created a scientific knowledge base on which today's industry is built, and provides the platform for the agriculture and food sectors to play a central role in the knowledge-based bioeconomy of the future. Teagasc is deeply involved in exciting areas, such as functional foods, which combine potential health benefits and nutrition. The huge potential of the biotechnological revolution to transform the productivity of the agri-food sector is currently only partially grasped, presenting an ongoing challenge for Teagasc in the years ahead". The book is available from Teagasc's publications office, Tel: 059 9183409, and costs €30 (€15 for staff or retirees).



Teagasc hosts ABIC 2008

Teagasc recently hosted an international agricultural biotechnology conference in Cork, which was attended by 450 delegates.

DR EWEN MULLINS, Teagasc Oak Park Crops Research Centre, reports on some of the main topics discussed.

"While investment in agricultural research and development is one of the prime drivers of growth in agricultural productivity, if we are going to meet the world's future needs for food, feed and fuel, we will need all the science and technology tools available," stated Professor Gerry Boyle, Director of Teagasc, at the opening of the Teagasc-hosted Agricultural Biotechnology International Conference (ABIC) at University College Cork, the theme of which was 'Agricultural biotechnology for a competitive and sustainable future'.

"Developments in science, including biotechnology, have over many years led to improved human nutrition; safer food; improved animal health; better soil management; improved use of fertiliser; enhanced varieties of crops; advanced control of insects, disease and weeds; superior methods of harvesting, storing and transporting farm products; and, many other contributions," Professor Boyle said. But, as outlined by Professor Patrick Cunningham, Chief Scientific Adviser to the Irish Government, in a keynote address entitled 'Four Challenges or One? Population, Food, Energy, Climate', there are serious challenges ahead, none more so than the necessity to double the current rate of global food production by 2050 in order to meet the requirements of the world's population, while offsetting the predicted impact of climate change.

Professor Jimmy Burke, Teagasc, and Chairman of the ABIC 2008 conference, told the opening session that: "Biotechnology has revolutionised 21st century agriculture and food production systems worldwide in a way not foreseen a mere 30 years ago. Various national reports have rightly identified biotechnology as one of the core technologies that Ireland and Irish industry must now embrace". Professor Burke went on to say: "Irish cereal farmers are the most productive in the world, partly because they have access to excellent varieties of wheat, produced by classical plant breeders. If they are to hold on to this record, farmers, and the industry generally, must be able to use the most appropriate and competitive technology in the future. In this regard, new biotechnological techniques such as marker-assisted selection are already making a difference".

Licensing

"Feed the hungry. Improve human health. Preserve the environment." These were three simple messages from Dr Roger Beachy. He said that agriculture in 25 years time will not be the same as agriculture was in the past. "Plants that are more



Pictured at ABIC 2008 in UCC are (from left): Professor Paddy Cunningham, Chief Scientific Adviser to the Government; Professor Gerry Boyle, Director of Teagasc; Dr Ganesh Kishore, Managing Director, Biotechnology Venture Capital, Burrill & Company, USA; and, Professor Jimmy Burke, Chairman, ABIC 2008.

drought tolerant, use less water, grow using less artificial fertiliser and are resistant to disease will be needed in the future". He said that "the scientific communities have learned much about how plants function and have combined knowledge of plant genetics, biochemistry, biotechnology and agriculture", and that, for the first time, they have identified the genes that can confer resistance to the disease fusarium head blight in wheat. President of the Danforth Plant Science Centre in the United States, which he described to delegates as an independent, non-profit research centre, Dr Beachy said that the Centre does not want to be controlled by the private sector and does not want the private sector to control the agenda and licensing on agricultural biotechnology.

This point was underlined by Dr Richard Jefferson, Chief Executive of Australian-based CAMBIA, an independent, international non-profit institute, which has pioneered the BiOS initiative (Biological 'Open Source'). This has resulted in the invention of new gene transfer technologies, which bypass patent restrictions, and has broadened the user base of these technologies. To date, over 200 companies and institutions have adopted the technology. "The public deserves, and the world requires, new approaches to using science in agriculture. We need to explore new ecologies of innovation where the tools and platforms are dynamic and shared, but the outcomes of their use can be as varied as the imagination and business models of their users," he said.

Energy

As global energy consumption continues to increase, technology solutions are required to support sustainable growth, explained Dr Ian Dobson, Business Technology Manager of British Petroleum (BP) Biofuels, PLC. He explained that the cost of feedstocks is the limiting factor and that BP are developing metabolic pathways, production processes and fuel formulations for the use of biobutanol. This provides for an increased energy output of 25% over ethanol, which translates to more miles per gallon without altering the composition of the car engine. Critical advancements in the isolation and characterisation of biomass degrading enzymes were highlighted by Dr David Weiner of Verenum Corporation, USA, and by Dr Maria Tuohy of NUI Galway, who outlined the research being conducted by Eirzyme Ltd in developing bioprocesses to convert biomass to energy in an efficient and sustainable manner.



Crop breeding and biotechnology

The application of and opportunities for crop enhancement through biotechnology were described by Professor Andrew Peterson, Director of the Plant Genome Mapping Laboratory at the University of Georgia, USA. Professor Peterson described how they have effectively partnered structural and evolutionary genomic research with production agriculture. This pioneering work has led to the identification of DNA markers that are closely associated with specific traits in mainstream crops. Dr Dan Milbourne, Teagasc Crops Research Centre, told delegates about the successful integration of biotechnology-based tools into the well-established potato-breeding programme at Oak Park. Using the STM3016 DNA marker that was developed by his team, Dr Milbourne said that: "This initiative will serve to underpin the existing breeding programme by enhancing its ability to screen for increased disease resistance". Similarly, the ongoing investigation into the genetic mechanisms underlying biomass yield in perennial ryegrass at the Teagasc Crops Research Centre were detailed by Dr Susanne Barth.

Animal biotechnology

The regulatory importance and commercial potential of DNA-based traceability systems was described by Dr Ronan Loftus of Identigen Ltd, who detailed how advances in animal genomics and molecular diagnostics have provided food retailers, processors and producers with the capability to identify and trace the source of meat produce through the entire supply chain, thereby generating value-added assurance for consumers. Dr Ruth Hamill, Teagasc Ashtown Food Research Centre, presented recent work aimed at identifying genetic variation associated with meat quality by characterising gene expression levels in crossbred cattle divergent for meat tenderness and intramuscular fat levels. Statistical analysis of microarray experiments revealed 101 genes that were differentially expressed in tough versus tender beef. The outcome of this work could provide a panel of differentially expressed genes and single nucleotide polymorphisms with predictive value for Irish beef quality, highlighting the potential to define and optimise management systems through the incorporation of genomic technologies.

Molecular pharming

The potential of biomanufacturing therapeutics was succinctly demonstrated by Professor Charles Arntzen, a founding director of the Biodesign Institute at Arizona State University, USA. A pioneer in the development of vaccines for disease prevention in both humans and animals, he described his current research, which is focused on the expression of pharmacologically active products in transgenic plants. In the same session, Dr Maurice Moloney of SemBioSys Genetics Inc described a novel approach for the production of human insulin. By expressing human insulin-coding DNA sequences in safflower, they have been able to produce significant quantities of insulin in the plant which, following extraction, can be used for the treatment of human diabetes. This product is at an advanced stage of development and is currently undergoing clinical trials.

In concluding the international conference, Professor Burke stated that: "The science of biotechnology is good for society and the agricultural industry, and we should take confidence from the fact that public health is protected by a very rigorous approval system," he said. "We now know, from 30 years of international research and development, that modern plants and food produced using biotechnology are safe," he concluded. This sentiment was underlined by Dr Eija Pehu, Senior Biotechnology Adviser to the World Bank, who stated that: "The experience of the World Bank over the last two decades has led the organisation to recognise the substantial contribution that biotechnology can make to sustainable food production, but also to underline the importance of strengthening the role of public research in agricultural biotechnology into the future".

Visit the conference web page at www.abic.ca/abic2008/index.html.



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Grazing during wet weather on Irish dairy farms

EMER KENNEDY and MICHAEL O'DONOVAN, Moorepark Dairy Production Research Centre, explain how it is possible to extend the grazing period of dairy cows up to 300 days a year, without showing a decline in milk yields.



Irish dairy production pivots on pasture-based systems, as grazed grass is the cheapest feed source available to Irish farmers and is cheaper by factors of 2.5 and 4.2 when compared to grass silage and concentrate, respectively. The competitive advantage of Irish dairy production over other European milk producing nations lies in the maximisation of the proportion of grazed grass in the diet of the lactating dairy cow. Greater profitability can ultimately be achieved by improving grassland management practices. Moorepark Dairy Production Research Centre has set an ambitious target of a 300-day grazing season under optimal grazing conditions; however, all farmers should be targeting an increased number of days grazing regardless of location.

Wet weather strategies

One of the main obstacles to achieving a greater number of days at grass is the inclement weather conditions experienced in early spring and late autumn. Traditionally during these periods, dairy cows remain indoors and are primarily offered grass silage. If cows remain in the paddock, treading damage caused

during periods of heavy rainfall can result in reduced growth rates during subsequent grazing rotations. Allowing animals access to pasture for a few hours per day has previously been shown to increase milk production and milk protein concentration when compared to grass silage-based diets and may be a strategy that can be implemented during periods of wet weather. In order to deduce the optimum grazing strategy that should be implemented during these periods of difficult weather conditions, a series of experiments was undertaken at Moorepark. During the first experiment the following treatments were investigated:

- i) full-time access to grass (22 hours);
- ii) one single nine-hour period (previous work at Moorepark has shown that lactating dairy cows graze for approximately nine to 10 hours per day) of access to pasture between morning and evening milking (animals were housed at night);
- iii) a nine-hour period split into two equal periods, i.e., 4.5 hours after morning milking and 4.5 hours after evening milking (2x4.5); and,

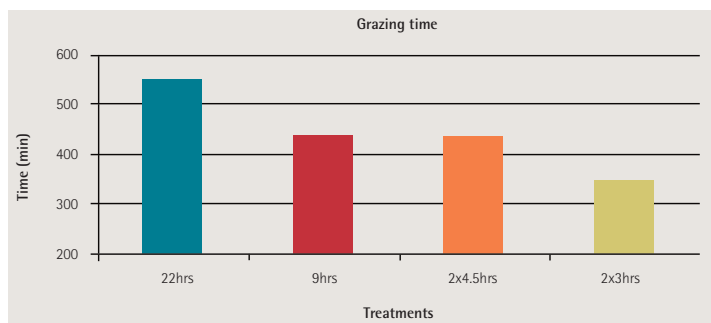


FIGURE 1: Effect of restricting access to grass on the grazing time of cows in four different treatments.

- iv) two three-hour periods of access to grass after each milking (2x3), as when access time to pasture is restricted animals have to focus their grazing activity and may not need as long a grazing period.

All the cows were given the same feed allocation (a daily grass allowance of 15.5kg dry matter [DM]/cow/day and 3kg DM/cow/day of concentrate). When the cows were not grazing they returned indoors and were not offered any additional feed, ensuring that they had an appetite at grazing times.

Results

Interestingly, following the 31-day experimental period there was no difference in the milk yield of the mid-lactation autumn-calving cows. Milk protein concentration was significantly lower for the 2x3 treatment (3.34%) when compared to the control treatment of full-time turnout (22 hours; 3.51%). Total DM intake was significantly reduced by allocating cows one nine-hour period (15.1kg DM/day) for grazing compared to the 22-hour treatment

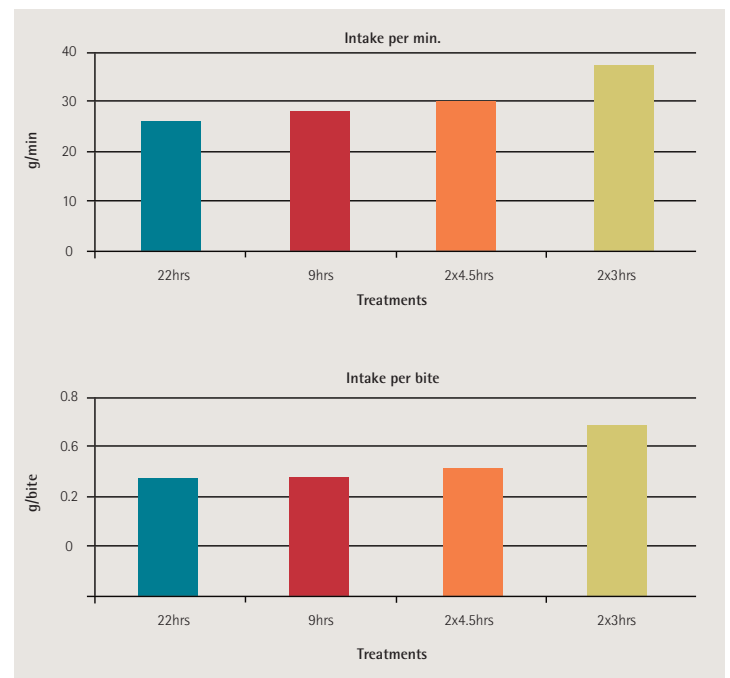


FIGURE 2: Effect of restricting access to grass on the intake per minute and intake per bite of cows in four different treatments.

(16.8kg DM/day). There were no differences in body weight and body condition score. The lack of differences between treatments can be attributed to the cows' capacity to adjust their grazing behaviour depending on the imposed situation. **Figure 1** shows the grazing time of each of the four treatments. It is clear from this graph that the cows focused their grazing activity and became extremely efficient grazers. For example, the 2x3 treatment had a total of six hours access to pasture and grazed for 5.8 hours, or 96% of the allocated time. It was also interesting to note that both the 2x4.5 and 2x3 treatments achieved 95% (16kg DM/cow/day) of the dry matter intake of the 22-hour animals (16.8kg DM/cow/day). This can be attributed to the animals' alteration of intake per minute and intake per bite. When animals are allocated full-time access to pasture, intake per minute is approximately 26g, while intake per bite is 0.47g. The 2x4.5 and 2x3 cows increased their intake per minute (30.1 and 37.6g/min, respectively) and intake per bite (0.52 and 0.69g/bite, respectively) to compensate for the reduced access time to pasture (**Figure 2**).

T Livestock



Poaching, evident in the foreground of the picture, can be prevented by restricting access to pasture during periods of inclement weather.

From this experiment, it is clear that restricting cows' access to pasture has no effect on the milk yield of mid-lactation dairy cows. However, milk protein concentration was reduced when pasture access time was restricted to two three-hour periods, while dry matter intake was reduced when cows grazed for one single nine-hour period. Thus, it can be concluded from this study that during inclement weather conditions, mid-lactation dairy cows should be given access to pasture in two distinct periods and that each of these periods should be greater than three hours.

However, a number of questions still remain, such as, should cows be supplemented with additional feed when they return indoors; or, would early lactation cows react differently to mid-lactation cows? A second experiment was undertaken in Moorepark this spring using spring-calving cows in early lactation. Given that it appears that pasture access time should be split into two distinct periods, the nine-hour treatment from the previous spring was substituted with a treatment that offered cows 3kg DM/cow grass silage when the cows were indoors at night. The access time of these cows was two three-hour periods. The 22-hour, 2x4.5 and 2x3 treatments were repeated. Preliminary results suggest that, again, there is no difference in milk yield between treatments; however, milk protein concentration was significantly reduced by including grass silage in the diet.



Cows returning indoors after grazing for three hours after morning milking.

Conclusions

From these studies it is evident that high levels of performance can be achieved from grazed pasture during periods of inclement weather. However, these studies have indicated that access time should be split into two separate periods (preferably after each milking) and that each period should be of at least three hours duration. Also, the animals should not be supplemented with additional feed (grass silage) when they return indoors as this will have negative effects on milk protein concentration.

This research was funded by the Teagasc Core Programme.

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The Grange blueprint for suckler beef

PAUL CROSSON, MARK McGEE and MICHAEL DRENNAN, Teagasc, Grange Beef Research Centre, summarise current performance levels on Irish beef farms, outline the Teagasc Grange suckler beef blueprint for profitable production, and introduce some Teagasc initiatives to drive technology transfer and profitability for beef farms.



Current performance

Beef farming in Ireland has been characterised in recent years by low family farm incomes. A brief analysis of Teagasc National Farm Survey (NFS) figures shows that, on a market basis, cattle farms in Ireland are operating at a significant loss (**Table 1**). Clearly, higher prices for beef would improve profitability, as would a pricing structure that rewards superior quality carcasses (the source of which is the suckler herd). However, within the farm gate the factor contributing most to the poor economic returns is the low level of physical and financial output. NFS data illustrate the extensive nature of suckler beef systems in Ireland, with gross output values of only €459/ha and €563/ha for breeding and non-breeding farms, respectively. These low levels of output are primarily a result of low stocking rates. Under-stocking on beef farms results in low grazed grass utilisation. As grass is our cheapest feed, maximising its utilisation is a key component of the profitability of beef systems.

Other issues of importance include reproductive performance, live weight performance and level of fixed costs. Since the mid-term review of the Common Agricultural Policy, farm support payments have been decoupled from production and, thus, systems of production must return a market-based net margin for those systems to remain sustainable.

Grange suckler beef blueprint

Research at Grange continues to provide the guidelines for profitable suckler beef production systems. The current blueprints are based on a number of years of systems research and are presented in **Table 2**. Two production systems are described: steer and bull systems. These can be operated at two stocking rates, standard (205kg organic N/ha) and extensive (165kg organic N/ha). The blueprints are for spring-calving, continental crossbred cow herds. Heifers are finished at 20

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months of age at carcass weights of 310kg at the end of the second grazing season. In the steer system, males are castrated and finished at 24 months of age at carcass weights of 390kg following their second winter. In the second system, bulls are finished at 16 months of age at carcass weights of 360kg. Cows are bred to a Charolais sire and heifers are bred to an easy-calving Limousin sire. While the stocking rate for the standard system is above the limits set by REPS 3 and the Nitrates Directive, it is applicable for REPS 4 for farmers with a derogation from the Nitrates Directive. The extensive system is applicable for farmers in REPS 3 and is within the limits of the Nitrates Directive. The systems are based on the following principles:

1. High physical output: It can be seen from **Table 2** that the stocking rates and carcass output for the Grange blueprint systems are high. By matching high output with good carcass prices (good conformation, lean carcasses) gross output values are high.
2. Maximising the quantity of grazed grass in the annual feed budget: Grazed grass accounts for approximately 60% of the annual feed budget in calf-to-beef systems. A high rate of live-weight gain during the grazing season is achieved by presenting leafy swards of high digestibility material to the herd at all times.
3. A breeding programme focused on cows with good maternal traits bred to high performance terminal sires: At Grange, lifetime gains average 945g per day in the steer system and 1,085g per day in the bull system. To achieve this target, the suckler cow must have adequate milk yield (nine to 12 litres per

day) and both the cow and terminal sire must produce offspring with high growth rate and good conformation. A key component of the breeding programme is maximising hybrid vigour by using a sire of a third breed on a crossbred cow.

4. Good reproductive performance: Good fertility is essential for profitable suckler beef production. The average pregnancy rate at Grange is 94%, with a calving interval of 367 days. Rebreeding is mainly at grass in May and June. Cows are turned out in moderate body condition and provided with adequate grass supplies to allow for recovery of body reserves and ensure good reproductive performance. Artificial insemination is mainly used and, therefore, it is essential to have effective heat detection in order to achieve good reproductive performance.

Farmers that will thrive under the future opportunities are those who will operate efficient systems of production, maximising lifetime gain from grazed grass to contain costs and produce and market a premium, certifiable-quality product.

TABLE 1: Summary of NFS financial results excluding direct payments (€/ha) for cattle farms in 2007.

	Income (€/ha)	
	Breeding systems ¹	Non-breeding systems ²
Gross output	459	563
Gross margin	182	237
Net margin	-182	-159

¹Suckler beef farms selling progeny as weanlings, stores and finished cattle.

²Mixed livestock and finishing farms.

TABLE 3: Sensitivity analysis of net margin in Grange blueprint suckler systems (€/ha).

	Steer		Bull	
	Standard ¹	Extensive ²	Standard	Extensive
Market-based net margin	297	254	395	323
REPS ³	220	220	220	220
Suckler Welfare Scheme ⁴	100	80	114	91
Concentrates price change ± €60/t	40	36	62	53
CAN price change ± €75/t	71	43	63	38
Beef price change ± 35c/kg	179	144	197	157

¹Standard system: compatible with REPS 4 with nitrates derogation.

²Extensive system: compatible with REPS 3 and Nitrates Directive.

³Participation costs must also be considered.

⁴Participation costs must also be considered.

TABLE 2: Production and financial targets for the Grange blueprint suckler systems.

	Steer		Bull	
	Standard ¹	Extensive ²	Standard	Extensive
Production targets				
Physical stocking rate (LU/ha)	1.95	1.55	1.95	1.55
Organic N applied (kg/ha)	205	165	205	165
Fertiliser N applied (kg/ha)	195	85	170	70
Cow numbers (on 40ha)	50	40	57	45
Weaning weight ³ (kg)	303	303	303	303
Slaughter weight ³ (kg)	350	350	330	330
Lifetime performance ³ (g/day)	945	945	1,085	1,085
Carcass output (kg/ha)	548	440	596	477
Concentrates fed per cow unit ⁴ (kg)	710	710	950	950
Financial targets (€/ha)				
Gross output	1,826	1,465	1,998	1,599
Gross margin	846	759	948	829
Market-based net margin	297	254	395	323
Net margin incl. REPS ⁵ and SWS ⁶	617	554	729	634

¹Standard system: compatible with REPS 4 with nitrates derogation.

²Extensive system: compatible with REPS 3 and Nitrates Directive.

³Average of males and females.

⁴Cow plus progeny to slaughter including replacements.

⁵Participation costs must also be considered; ⁶Suckler welfare scheme; participation costs must also be considered.

Economic performance

Table 2 presents the economic performance of the Grange blueprint systems. The key component of the profitability of the Grange systems is the high level of gross output. Output value, variable and fixed costs, and gross and net margins are higher for the standard system relative to the extensive system. The bull system outperforms the steer system at current costs and beef prices. In both instances, higher output is the key determinant of the advantage. The market-based net margin ranges from €254/ha for the extensive steer system to €395/ha for the standard bull system. These margins are increased considerably when REPS and Suckler Welfare Scheme payments are included. It should be noted that securing a market for finishing bulls is essential before commencing to finish males as bulls. Farmers also need be cognisant of the higher labour and capital requirements of the higher output systems.

The high output levels of the Grange systems correspond to relatively high levels of variable costs. It should be noted, however, that although variable costs account for approximately 50% of gross output, this is somewhat less than the respective value for NFS farms. For all scenarios, conventional housing facilities are assumed and the respective depreciation and interest charges are accounted for in the fixed costs. Given the increased volatility of beef prices and input costs in recent times, the impact of price changes on profitability is of interest. Therefore, **Table 3** presents a sensitivity analysis of the profitability of the Grange blueprint systems and highlights the relative impact of REPS, the Suckler Welfare Scheme, concentrate price, fertiliser price and beef price on the net margin. On a per hectare basis,



Terry Carroll (right), Teagasc Business & Technology drystock advisor and Paul Farrell, Kilkenny, BETTER Farm Programme member.

REPS, as an area-based payment, is the same for all scenarios, whereas the Suckler Welfare Scheme, as an animal-based payment, is greater for the higher stocked systems. These payments have a large role to play in improving the profitability of suckler beef systems such that net margin is more than doubled in the extensive steer system, while still allowing €46/ha (€1,840 on a 40ha farm) for participation costs. The bull systems have higher concentrate requirements and are, therefore, considerably more sensitive to concentrate price changes. Similarly, the steer systems are more sensitive to fertiliser price changes (due to higher fertiliser application rates), although in this case the difference in sensitivity is modest. For both concentrates and fertilisers, the standard systems are more sensitive to price changes than the extensive systems. The analysis reinforces the importance of beef price, with a 35c/kg increase in the current price increasing market-based net margin by approximately 60% in the steer systems and 50% in the bull systems. This emphasises the importance of beef price and a pricing structure that rewards producers of superior quality carcasses. Consequently, farmers that will thrive under the future opportunities are those who will operate efficient systems of production, maximising lifetime gain from grazed grass to contain costs and produce and market a premium, certifiable-quality product.

Initiatives

It is apparent that there is considerable divergence between the performance on many beef farms and the targets set by the Grange suckler beef blueprints. Two initiatives are being instigated to further the transfer of profit-enhancing technologies and boost profitability on beef farms:

1. *Teagasc beef systems research farm*: Teagasc has committed to the establishment of a systems research farm to demonstrate best practice for beef production systems.
2. *Teagasc-Irish Farmers Journal BETTER (Business, Environment, Technology through Training, Extension and Research) Farm Programme*: This project will involve an intensive on-farm monitoring programme to identify current performance levels, a work plan to target key areas for improvement and an intensive advisory programme to drive technology transfer and profitability.

In tandem with a comprehensive research programme, these initiatives will ensure that Grange continues to provide clear leadership to the beef sector. With the opportunities that will present themselves in the coming years, the objective is to provide a road map for significant improvements in profitability for progressive and profit-focused farmers.

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Stress test in cattle

Physiological activation of the hypothalamus–pituitary–adrenal (HPA) axis in steers has been investigated by DR BERNADETTE EARLEY, Teagasc, Animal Bioscience Centre, Grange, Co Meath.

Activation of the hypothalamus–pituitary–adrenal (HPA) axis is the main defining feature of the stress response. Under the influence of both internal and external stressors, activation of the HPA axis causes increased synthesis of corticotropin-releasing hormone (CRH) in the hypothalamus, and its release into the circulation within a few seconds of the onset of stress. Hypothalamic CRH is a neuropeptide responsible for the endocrine, autonomic, immunological and behavioural responses of mammalian organisms to stress (Moberg, 2000). The major role of CRH is the regulation of the HPA axis through secretion of both basal and stress-induced release of adrenocorticotrophic hormone (ACTH) from the anterior pituitary gland and glucocorticoids (cortisol) from the adrenal gland (Figure 1). Hypersecretion of CRH elicits anxiogenic-like effects and immunosuppressive activity, decreases food intake, reduces weight gain, modulates locomotor activity and limits the efficiency of reproduction by decreasing secretory activity of cells producing growth hormone (GH) and gonadotropin-releasing hormone (GnRH) in the cow (Smith and Dobson, 2002). The objective of this study was to determine an appropriate dosage of bovine (b) CRH (bCRH) following exogenous administration to simulate physiological activation of the HPA axis in steers, and to determine how different doses of bovine bCRH affect plasma ACTH and cortisol concentrations.

Materials and methods

Twenty, 14-month-old Holstein-Friesian steers were blocked by body weight (BW; mean 443.7 ± 2.5 kg), and within block were assigned to receive either saline (control; 2 ml, 0.89% NaCl) or bCRH (0.1, 0.3, 1.0, or $1.5 \mu\text{g/kg}$ BW) treatments. The steers were housed in a slatted floor facility, with one steer

from each treatment in each pen (3.8 x 4.5 m; $n = 5$ animals per pen). Before assignment to treatment, steers were housed for a two-week acclimatisation period to get accustomed to the housing environment and tethering by restraining them daily for two hours each morning. Steers were given *ad libitum* access to grass silage (dry matter [DM] = 887 g/kg) supplemented with 2.5 kg of a barley/soybean mix (values on DM basis, crude protein [CP] = 155 g/kg, crude fibre = 41.9 g/kg, acid hydrolysable oil = 39 g/kg, ash [mineral matter] = 58.6 g/kg) per steer daily. Steers had free access to water troughs in the individual pens.

bCRH challenge

On day 0, bCRH- (American Peptide Company, Inc., Sunnyvale, CA) administered steers received either 0.1, 0.3, 1.0 or $1.5 \mu\text{g}$ bCRH/kg BW, and control animals received normal saline (IV) through an in-dwelling jugular catheter between 0815h and 0827h. At the time of bCRH and saline administration, steers were haltered and tied to the feed barrier in front of the pen. They were free to lie and stand. To facilitate intensive blood sampling, in-dwelling jugular catheters were fitted aseptically on the day before start of treatment (d-1). Serial blood samples were collected at -15 and 0 minutes before bCRH and saline administration, and at 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180, and 195 minutes after administration. Blood samples were collected into vacutainer tubes containing heparin and EDTA (anticoagulants) for cortisol and ACTH assays, respectively.

Results

The degree of HPA axis activation was obtained by determining the ACTH and cortisol responses after bCRH administration. The results showed a stimulatory

TABLE 1: Effect of bCRH on plasma ACTH and cortisol concentrations in steers. Means (\pm SEM) are presented for the peak response and for the data relating to the overall ACTH and cortisol response, while median, lower (min) and upper (max) quartiles are presented for the data relating to the peak interval.

		bCRH dose $\mu\text{g/kg}$					SEM	P <
		Control	0.1	0.3	1.0	1.5		
ACTH peak (pg/ml)	Mean	-	126	228*	232*	269*	60.8	0.01
ACTH peak interval** (min)	Median	-	30	30	30	30		0.06
	(Min-max)	-	(15-30)	(15-30)	(30-30)	(30-30)		
Overall ACTH, pg/ml	Mean	43.7 ^a \pm 7.85	64.7 ^{ab} \pm 8.42	89.6 ^{bc} \pm 5.61	103.6 ^{bc} \pm 19.3	111.5 ^c \pm 16.99		0.01
Cortisol peak (ng/ml)	Mean	-	36.9*	35.6*	43.8*	41.1*	4.39	0.001
Cortisol peak interval** (min)	Median	-	30 ^a	60 ^b	52.5 ^b	67.5 ^b		0.002
	(Min-max)	-	(30-45)	(45-60)	(45-60)	(45-75)		
Overall cortisol, ng/ml	Mean	3.2 ^a \pm 0.54	23.5 ^b \pm 3.39	23.5 ^b \pm 2.56	29.3 ^b \pm 1.65	28.2 ^b \pm 4.21		0.001

*Significantly elevated ($P < 0.05$) above pre-treatment baseline concentrations (ACTH = $38.4 \pm 2.26\text{pg/ml}$; cortisol = $1.52 \pm 0.19\text{ng/ml}$).

**Peak interval was the time taken (min) to reach peak values.

^{a,b,c} Values within a row with different superscripts differ significantly ($P < 0.05$).

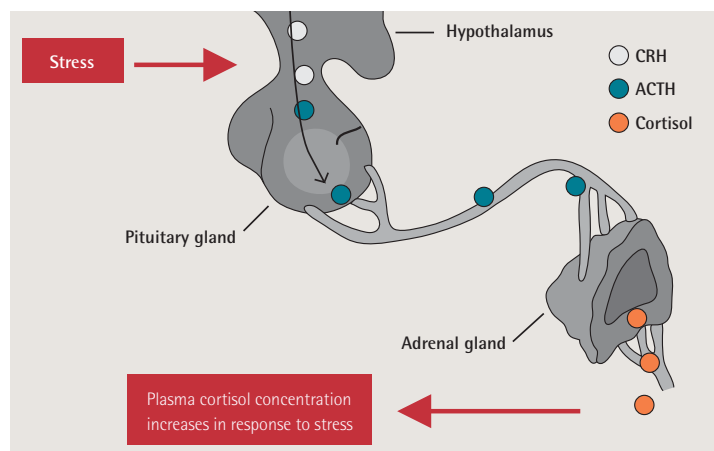


FIGURE 1: Hypothalamus-pituitary-adrenal (HPA) axis.

effect of bCRH, initially on the pituitary gland, and subsequently on the adrenal gland of steers, as indicated by the changes in plasma concentrations of ACTH and cortisol (Table 1). The response to exogenous bCRH was evident after administration of 0.1 μg bCRH/kg BW, with all steers responding at 0.3 μg bCRH/kg BW. In this study, peak concentrations of ACTH ranged between 126 and 269 pg/ml for dosages between 0.1 and 1.5 μg bCRH/kg, and were greater than baseline concentrations (mean concentrations as measured at -15 and 0 minutes before bCRH administration). Following administration of 0.1 μg bCRH/kg BW, the mean peak ACTH response was not different ($P > 0.05$) from pre-treatment baseline concentrations. Administration of 0.3, 1.0, and 1.5 μg bCRH/kg BW increased peak ACTH ($P < 0.05$) above pre-treatment baseline concentrations (Table 1). The peak responses for cortisol in all bCRH treatments were greater ($P < 0.05$) than pre-treatment baseline concentrations (Table 1).

In summary, the overall mean response for ACTH concentration following 0.1 μg bCRH/kg was not different ($P > 0.05$) from controls, whereas the mean ACTH response following administration of 0.3, 1.0 and 1.5 μg bCRH/kg was

greater ($P < 0.01$) than in controls, indicating that ACTH levels varied depending on the dose of bCRH administered.

The overall mean cortisol response was greater ($P < 0.01$) in all bCRH-treated steers compared with saline-treated steers. There was no difference ($P > 0.05$) in the cortisol response among the bCRH treatments.

In conclusion, a bCRH challenge is useful for testing the sensitivity of the HPA axis in steers and a minimum dose of 0.3 μg bCRH/kg BW is required to simulate physiological activation of the HPA axis by the stressor hormones, ACTH and cortisol.

Implications

Stressful events alter the functioning of the HPA axis. Altered HPA axis associated with decreased functions of the immune system may lead to greater disease susceptibility in farm animals. Administration of CRH at the dose rate of 0.3 μg per kilogram of body weight will induce ACTH and cortisol release, and may be used to test the sensitivity of the pituitary and adrenal glands during stress in cattle.

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Image courtesy of Bord Bia

Marbling in beef: what determines its content?

GERRY KEANE and AIDAN MOLONEY discuss work being carried out to determine what affects beef fat content at Teagasc, Grange Beef Research Centre.

Consumers are understandably concerned about the quality of their food, particularly meat. There are many definitions of quality, some of which have little basis in fact and/or cannot be objectively defined. An objective measure of one important aspect of meat quality is chemical composition, namely the proportions per unit weight of dry matter (or moisture), protein, fat and mineral matter. These determine the overall energy and nutritive value of the meat.

Beef production in Ireland is based on a wide diversity of breeds and production systems. Such diversity has practical advantages in that it facilitates the production of carcasses suited to a wide range of markets. This is very important, as 90% of our production is exported. However, it also results inevitably in large variations in carcass and meat composition. These variations, particularly in fat content, are a

source of concern for consumers, as the fat content of beef is often unknown at the point of purchase.

Even when all separable fat is removed, lean meat can still vary considerably in its intramuscular or 'marbling' fat content. The only way of accurately establishing the amount of this fat is by chemical analysis. A certain minimum level of marbling fat is necessary for adequate flavour and juiciness, and while there is no agreement on the optimum level, there seems to be general acceptance that once it reaches 25-30g/kg, further increases result in little further improvement in eating quality.

Compared with Ireland, a much lower level of marbling fat is the norm in countries of central and southern Europe, whereas a considerably higher level obtains in the US. Japan is an extreme case, where very high levels are desired.

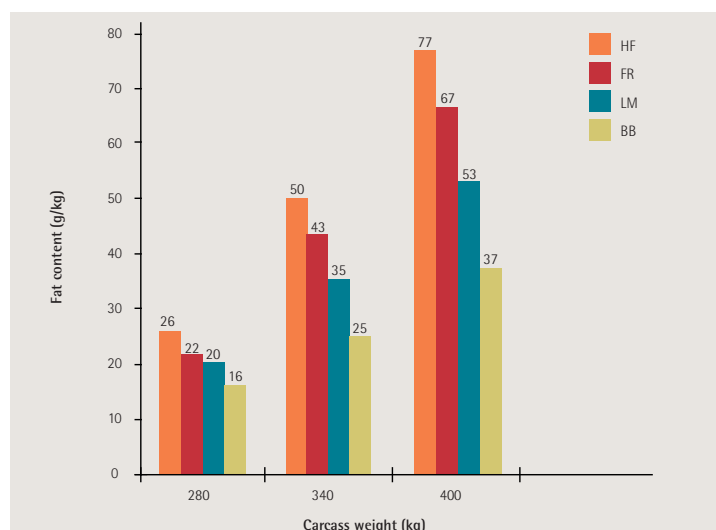


FIGURE 1: Marbling fat in beef striploin – effects of breed and carcass weight.

What determines marbling?

The marbling fat content of beef is entirely a function of the fatness of the animal at slaughter, which in turn is a function of on-farm production factors. Thus, if beef marbling fat content is to be altered, it must be done by the producer before the animal is slaughtered. Farmers in beef production for profit and will, by and large, produce the type of carcasses that are most profitable. If there is a disconnect between what consumers require and what farmers produce, this is because the consumer requirements are not transmitted to the producers and/or there is no accompanying financial incentive. It is the responsibility of the beef industry – processing and retail sectors – to interpret consumer requirements, convert them to reasonably precise and measurable carcass specifications, and underpin them with a realistic payment schedule for the different types of carcasses. Otherwise, producers will either not receive, or will ignore the signals from consumers, and continue to produce what they perceive to be most profitable.

Determination of beef carcass composition

As cattle grow and mature, their body composition changes, both physically and chemically. When young, the body mainly comprises muscle and bone with little fat. From early in life, bone growth slows and becomes a decreasing proportion of the increasing body weight. Muscle growth accelerates for a period after birth, but ultimately slows down, and from that point on it too becomes a decreasing proportion of the increasing body weight. Fat growth is very slow for a considerable period after birth, but once the onset of fattening commences, fat proportion increases rapidly (in conditions of adequate nutrition), and it becomes an ever-increasing proportion of the increasing body weight. Changes in carcass composition parallel those for the overall body, and actual carcass composition is entirely dependent on the point in the growth process at which the animal is slaughtered. Carcasses from immature animals will have high muscle and bone proportions and low carcass and marbling fat

TABLE 1: Effects of finishing system on carcass and muscle fat proportions, and taste panel traits.

	Finishing system	
	Indoors	Pasture
Carcass weight (kg)	363	366
Carcass fat (g/kg) ¹	152	129
Fat depth at ribs (mm)	14	9
Kidney and channel fat (g/kg) ²	26	17
Muscle fat (g/kg)	60	47
Taste panel traits³		
Juiciness	4.2	4.1
Tenderness	5.4	5.6
Flavour	2.9	3.2
Overall acceptability	2.5	2.6

¹Of pistola; ²Of carcass; ³Scale 1 to 8 (best) for juiciness and tenderness; Scale 1 to 4 (best) for flavour and overall acceptability.

proportions. In contrast, carcasses from more mature animals will have lower muscle and bone proportions and higher carcass and marbling fat proportions.

Muscle chemical composition

The typical chemical composition of beef muscle from Irish carcasses is about 720g/kg moisture, 230g/kg protein, 40g/kg fat and 10g/kg ash (mineral matter). Generally, protein proportion remains reasonably constant but moisture and fat proportions vary inversely with each other as overall carcass composition changes. Within the same animal, chemical composition can differ for different muscles. Fat content is lowest and moisture and protein contents are highest in the limb muscles. Next in fatness are the loin muscles followed by the flank and chest muscles and, ultimately, the rib muscles.

It is the responsibility of the beef industry – processing and retail sectors – to interpret consumer requirements, convert them to reasonably precise and measurable carcass specifications, and underpin them with a realistic payment schedule for the different types of carcasses.

Muscle composition by breed and weight

Before the start of finishing, store cattle have a muscle chemical composition of about 750g/kg moisture, 230g/kg protein, 10g/kg fat and 10g/kg ash. As fattening progresses, the moisture and protein proportions decline and the fat proportion increases – but at different rates for different breed types. The fat

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content of loin muscle at 280kg, 340kg and 400kg carcass weight for the progeny of Friesian (FR), Hereford (HF), Limousin (LM) and Belgian Blue (BB) sires out of Friesian dairy cows is shown in **Figure 1**.

For all breeds, the fat content of the muscle increases with increasing carcass weight and is, on average, nearly three times greater (59 vs. 21g/kg) at 340kg than at 280kg. There is a large difference between breed types, which increases as carcass weight increases. At 280kg carcass weight, the difference between Hereford and Belgian Blue is just 10g/kg (26 vs. 16g/kg), but by 400kg that difference has increased to 40g/kg (77 vs. 37g/kg). The rate (per 100kg) of increase in muscle fat with increasing carcass weight is greatest for Hereford (42.5g), followed by Friesian (37.5g), then Limousin (27.5g) and, finally, Belgian Blue (17.5g). Herefords have as much marbling fat at 280kg carcass weight as Belgian Blue at 340kg carcass weight, while Limousin have as much at 340kg carcass weight as Belgian Blue at 400kg carcass weight. Clearly, where low marbling fat is desired, Friesians and early maturing breed types should be slaughtered at relatively light carcass weights. However, if late maturing types like Belgian Blue are slaughtered at light weights, their meat quality may be impaired because of inadequate marbling fat. Such breed types need to be taken to heavier slaughter weights to ensure adequate marbling fat content.

Finishing system and marbling fat

Because of the degree to which age, feeding system and carcass weight are confounded, it is difficult to partition their effects on muscle marbling, but there is considerable evidence that, at the same weight, animals finished off pasture have less overall fat, and consequently less marbling fat, than those finished indoors on silage and concentrates. Charolais x Friesian steers were finished conventionally over the winter on silage plus concentrates and slaughtered at about two years of age. A comparable group was stored over the winter and finished off pasture at about 29 months of age. Carcass weight was similar for both groups, as intended. All measures of fatness were lower for the pasture finished animals (**Table 1**), including marbling fat. There were no significant differences between the finishing systems for taste panel traits.

Predicting marbling fat from carcass traits

Two traits routinely measured at slaughter that might be expected to be good predictors of muscle marbling fat are carcass weight and carcass fat class. As shown earlier, the relationship between carcass weight and marbling fat

content varies with breed type, so while carcass weight is a reasonable predictor within breed, it is useless for across breed prediction. Even within breed it may not be equally reliable for all breeds. In a data set from Grange, carcass weight predicted muscle marbling fat better for Friesians than for Charolais crosses. This may be a consequence of the lower marbling in the Charolais crosses and the effects of small analytical and experimental errors on these low values.

Interestingly, there was no difference between the breeds in the accuracy with which carcass weight predicted muscle moisture content, and the accuracy of moisture prediction was much higher than for marbling fat prediction. Since moisture content is closely related to marbling fat content, and may be more reliably and consistently predicted from carcass traits, perhaps the best approach would be the prediction of moisture content from carcass traits and then prediction of marbling fat content from the predicted moisture content. While carcass fat class was a useful predictor of carcass fat proportion, it was of little use in predicting marbling fat content. Thus, while marbling fat content is extremely important in terms of the healthiness, wholesomeness, nutritive value and eating quality of beef, as yet there is no simple way of predicting it from routinely recorded carcass traits. It is possible that the automatic carcass grading machines, now installed in slaughter plants, could be modified to either measure marbling directly or predict it from measures of carcass fat. Alternatively, hand-held instruments are being developed to measure marbling fat content in the boning hall.

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Conclusions:

- consumers are demanding and are entitled to information on the fat content of beef;
- this is entirely determined by production factors and is fixed at the farm gate;
- the effects of the various production factors on carcass and beef fatness are well understood and have been widely elaborated;
- the production factors with the greatest effects on marbling fat content are breed type and slaughter weight, but other factors, such as level of feeding and type of diet, also play a role;
- at constant carcass weight, marbling fat content is higher for early maturing beef breeds than for Friesians, and for Friesians than for late maturing beef breeds;
- marbling fat content increases with increasing slaughter weight, and does so more rapidly for early maturing breeds than for Friesians, and for Friesians than for late maturing breeds;
- cattle finished off pasture in their third grazing season have lower values for all measurements of fat than animals of similar carcass weight finished at two years of age off silage plus concentrates;
- carcass weight is a moderately reliable predictor of marbling fat content within breed but not across breeds (because of the differences between breeds in the relationship between carcass weight and fatness);
- carcass fat class is only moderately predictive of marbling fat content; and,
- the best option for the prediction of marbling fat in carcasses would appear to be modification of the existing automatic grading machines to include that capability.

Impact of grazing on the Teagasc Hill Sheep Farm

MICHAEL WALSH, Sheep Research Department, Teagasc, Athenry, reports on the impact of grazing on vegetation composition and wildlife habitats in the mountain landscape of the west of Ireland.



Teagasc Hill Sheep Farm in the Erriff valley, with the Maumtrasna Mountains in the background and a neighbouring commonage in the immediate foreground.

The Scottish Blackface hill sheep breed, which provides breeding stock for the lowland sector, is the main breed on the hill and mountain landscape of Ireland's western seaboard. This landscape extends over a million hectares and has a mild, western maritime climate. Annual rainfall totalling 2,000–2,500mm is fairly evenly distributed throughout the year. It harbours a number of habitats with unique plant communities, which, due to their limited global distribution, are of international importance. The soils consist of a high proportion of peat, which renders the landscape highly sensitive to changes in land use and/or

weather conditions. The condition of the habitats in many of the hill areas is a continuing source of concern. The impact of hill sheep on the vegetation was studied on the Teagasc Hill Sheep Farm at Leenaun. A summary of recent research information on the vegetation cover and habitats is presented.

Teagasc Hill Sheep Farm

The farm is located in the Erriff River Valley in Connemara, approximately 6km from the village of Leenaun on the Galway–Mayo border. It extends over 270ha

T Livestock

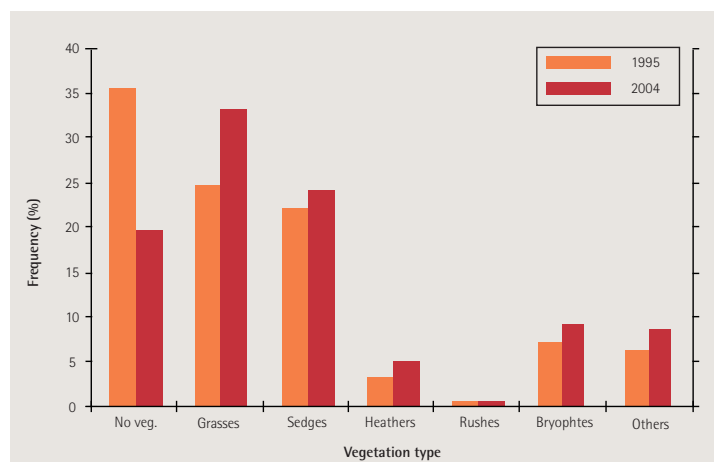


FIGURE 1: Changes in general vegetation occurrence from 1995 to 2004, Teagasc Hill Sheep Farm, Leenaun.

on the eastern spur (shoulder) of Ben Gorm (c. 700m O.D.), which is part of the Sheeffry mountain range. Unimproved, semi-natural vegetation occupies approximately 230ha, ranging in elevation from 15 to 275m above sea level, and it has a general southerly aspect.

Two physiographic elements (a steep mid-slope [average 23°] and a lower, more gentle, colluvial slope [average 8°]) occupy most of the farm. Peat (average depth of 0.54m) is the dominant soil, but mineral soils with humic/peaty topsoil also occupy a significant proportion of the farm. The annual stocking rate of the semi-natural vegetation during the study period from 1995 to the present was maintained at 0.8 to 0.9 ewes per ha.

Changes in vegetation

Purple moor-grass and black bog-rush (a sedge) dominated the semi-natural vegetation. There was no application of lime or artificial fertiliser during the study period. Changes in vegetation cover were studied by monitoring overall vegetation frequency on a grid basis, controlled grazing experiments, permanent grazing exclosures and sheep 'camps' (rest sites/vegetation islands).

Overall farm assessment

A grid (100m x 100m) was established on the semi-natural vegetation of the farm. This provided 226 intersection points, at each of which 100 observations were made at ground level during the summer period. This exercise was repeated on seven occasions from 1995 to 2004, inclusive.

The results, presented in **Figure 1**, indicate that the occurrence of 'no vegetation' (mainly bare ground covered by algae/vegetation litter) had almost halved since 1995. The consequent increase in vegetation occurrence was reflected in all groups except rushes, which accounted for less than 1%. The occurrence of heathers, while low in 1995 (3%), had the largest proportional increase, followed by grasses and 'other forbes'. Individual species such as mat-grass and heath rush, which are indicative of intensive grazing and are unpalatable to livestock, remained static (at about 1.5%) from 1995 to 2004.

The substantial decrease in the area of 'no vegetation' and the restriction of unpalatable species to minimal amounts indicate that the stocking rate and grazing management had a beneficial effect on vegetation frequency and composition.

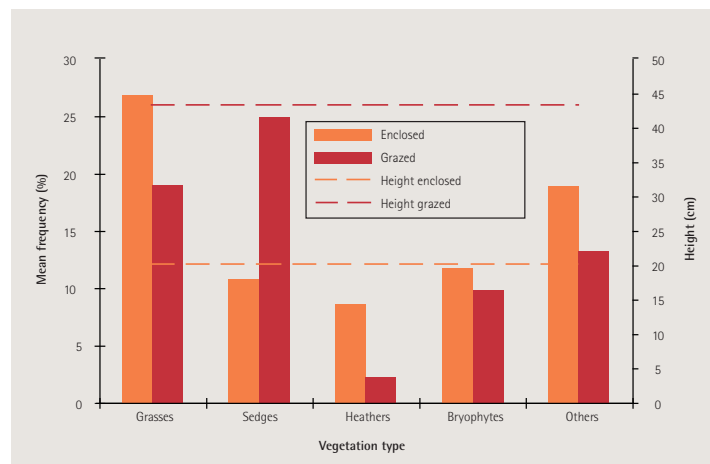


FIGURE 2: Effect of permanent exclosures, established in 1992, on vegetation frequency and height 13 years later.

Controlled grazing plots

Replicated grazing plots were established in 1995 and monitored to the present date to compare the effects of open grazing with exclusion of grazing during summer (May to October), winter (November to April), and the full year. The stocking rates for summer and winter were 1.1 and 0.8 ewes per ha, respectively. The exclusion of grazing in winter and in summer resulted in an increase in the occurrence of vegetation (7% and 19%, respectively) and a 25% increase in the full year exclusion in 2008. Heathers, which had a low base in all plots in 1995, showed increases in winter and summer exclusion (6% and 13%, respectively) and a similar increase to the above in the full-year exclusion over the same period.

Permanent exclosures

Ten permanent grazing exclosures representing the main differences in the unimproved vegetation of the farm were established in 1992. The results, presented in **Figure 2**, indicate that the average height of the grazed vegetation in the vicinity of the exclosures was 20cm, similar to that on the open hill, while within the exclosures the height was almost 45cm. The frequency of sedges in the grazed area increased, while that of grasses decreased. Heathers, although low in frequency, were significantly more frequent within the exclosures. The presence and increase of heathers in the exclosures that represented acid grassland suggested a succession towards a heath community.

Therefore, grazing at the present level compared with no grazing reduced overall vegetation height and restricted the occurrence of heather, but allowed higher species richness.

Sheep camps

A high proportion of the unpalatable mat-grass and heath rush species occurs in sheep camps, also called sheep rests or vegetation islands. Meadow grasses are also present and together they form a sharp contrast with the surrounding vegetation from late autumn to early spring when it is mostly decaying. These camps are also sites of repeated defecation by sheep and are thus likely to be extended in area over time or to be abandoned in favour of new sites. While



A GPS-collared, with other marked Scottish Blackface sheep, on the Teagasc Hill Sheep Farm.

they are individually small, and presently occupy about 2% of the area of semi-natural vegetation, they serve as an indicator of the sustainability of the existing stocking rate and grazing management system.

Use of hill resource

Sheep exhibit social group behaviour and tend to establish relatively stable ranges where they graze. Evidence from studies at Leenaun indicated a very uneven use of the open hill resource. Satellite tracking, using specially customised collars that were programmed to give locations at 10-minute intervals, was applied to randomly chosen ewes in August and September 2002. Over 14,000 locations were collected and, of the 217ha available for grazing, areas of intensive clustering accounted for just 36ha. While the frequency of vegetation on the hill had increased substantially from 1995 to 2004, the rate of increase within the areas of intensive clustering was significantly lower than elsewhere. Analyses of further satellite tracking data, using software for home range estimation on locations in spring time from 2004 to 2006, indicated that the ewes spent 95% of their time in an area ranging from four to 33ha from the same available area (217ha). General preference of habitat indicated that acid grassland and dense bracken were most preferred, while blanket bog was least preferred. Detailed preference analyses within the overall preference indicated no significant difference between habitats.

The issue of uneven use of the hill resource presents a challenge for land use management.

Related aspects of habitats

The definition and classification of heathland and peatland habitats, which are prevalent in the western hill and mountain landscape, focuses almost exclusively on vegetation composition. The aims of the EU Habitats Directive: "to promote the maintenance of bio-diversity", imply a more holistic interpretation, including human activities. Therefore, the population dynamics of small mammals such as wood mice and pygmy shrews, which are an important component of the food chain, were studied in a variety of habitats under different intensities of land use. While less numerous than in their normal woodland habitat, they are present in this landscape and appear to concentrate in the relatively dry wet heath rather than in the blanket



bog. The frequency of sheep occupation did not affect fitness (body weight) but differences compared with woodland, such as shorter breeding season (wood mice) and later attainment of breeding condition (pygmy shrews), were evident. Appropriate development of woodland/shrubland in suitable areas of the landscape would enhance the biodiversity of the habitats in conjunction with agricultural land use.

Conclusion and challenge

The present stocking rate and management system on the Teagasc Hill Sheep Farm resulted in an increased occurrence of vegetation, a halving of the area of 'no vegetation', and increased species richness, and maintained a low occurrence of species that are indicative of intensive grazing. The absence of grazing resulted in much taller vegetation and a decline in species richness. Satellite tracking and range analyses indicated that hill sheep spent most of their time on about one-sixth of the area that was available to them. The biodiversity of the habitats in this landscape can be enhanced in conjunction with sheep grazing and the development of appropriate woodland/shrubland.

The most immediate challenges to the hill resource include a more even use by hill sheep and controlling the spread of undesirable plant species such as mat-grass and heath rush.

Acknowledgements

The author gratefully acknowledges the assistance of L. O'Malley, Farm Manager, and P.J. Hastings of the Teagasc Hill Sheep Farm, Leenaun. Postgraduate students whose work contributed to the above were: Loreto Guinan, Niamh Quinn, and Bryony Williams.



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Increasing sow feed intake during lactation

PEADAR LAWLOR, Pig Production Development Unit, Moorepark, has been looking at ways to improve reproductive performance in sows through feed.



Ad libitum hoppers incorporated into existing troughs, Moorepark.

Feed intake of lactating sows is a primary determinant of performance in the breeding herd of any pig unit. Number of pigs born alive, farrowing rate and litters per sow per year can all be increased by increasing the intake of sows during lactation. For this reason, we in Moorepark have been looking at ways of increasing sow feed intake in the farrowing house.

The positives associated with high feed intake in lactating sows include:

- increased milk production/rearing capacity of the sow;
- speedy returns to heat after weaning;
- high numbers of pigs born alive at the subsequent farrowing;
- sows weaned in good body condition do not have to be overfed during gestation to correct body condition. Having to do this leads to reduced numbers born alive at the subsequent farrowing and reduced appetites in sows during the subsequent lactation; and,
- sows less prone to injuries, e.g., shoulder sores.

Liquid feeding

More than 50% of Irish sows are fed using computerised liquid feeding systems. For this reason our work initially focused on manipulating lactation feed curves for computerised liquid feeding as a means of increasing lactation feed intake. Frequently, producers inadvertently restrict the intake of liquid-fed sows during lactation by using feed curves that are too low to meet the intake capacity of the sows.

We conducted two experiments to look at feed curves. The feed curves that we evaluated are shown in **Figure 1**. Curve 1 was a lactation feed curve typical of those used on many commercial units, which should provide a mean daily lactation feed intake of 77MJ DE. Curve 2 was curve 1 increased by 15%, and curve 3 was curve 2 increased by 15%. Liquid feed was provided in two daily splits (am and pm) as a 4.1:1 mixture of feed (dry matter) to water by a computerised liquid feeding system. The lactation diet contained 14.2MJ DE per kg and 9.1g lysine per kg fresh weight. The experimental curves were fed between farrowing and weaning (ca. 28 days). *Ad libitum* access to the lactation diet was provided between weaning and oestrus. The objective in the first experiment (Experiment 1) was to determine the effect of

increasing the liquid feed allowance and providing supplemental dry feed to liquid-fed lactating sows on sow lactation feed intake, sow bodyweight loss and piglet performance to weaning. Treatments were: A. curve 1; B. curve 1 plus 1kg of dry lactation feed at midday from day 4; and, C. curve 2.

We found that treatments B and C both had higher mean lactation feed intakes than treatment 1 during each week of lactation. It was possible to achieve this increase in feed intake without much effort.

In a second experiment (Experiment 2) we looked at even higher levels of feed allowance for lactating sows. In this experiment we looked at increasing feed curves by a further 15% and feeding an additional 2kg of dry feed at midday to lactating sows. Treatments were: A. curve 2; B. curve 2 plus 2kg of dry feed from day 4; and, C. curve 3. A build-up of feed of up to 20% of the trough capacity was allowed at inspections one hour after feeding before curves were temporarily minused.

Again we found that we could increase the feed intake of lactating sows during each week of lactation by increasing the liquid feed curve on the computer or by giving supplemental dry feed (**Table 2**). Achieving these high feed intake levels required a considerable level of management. It was estimated that up to 50% of sows had to be deviated temporarily from the curve on a daily basis to prevent an excessive build-up of feed in troughs.

The additional workload associated with deviating individual sows on treatments B and C did, however, pay dividends. We found that weaning to oestrus interval was reduced from 10.4 days on treatment A to 6.1 days on treatment B and 5.1 days on treatment C ($P<0.05$). It was also found that number born alive at the next farrowing was numerically increased from 9.8 on treatment A to 10.8 on treatment B and 11.2 on treatment C.

From Experiments 1 and 2, we found that we could increase the feed intake of sows during lactation by 30% above those achieved with commonly used lactation feed curves. Alternatively, feed intake could be increased by feeding supplemental dry feed to liquid-fed sows. The increase in lactation intake achieved was found to improve subsequent reproductive performance. Previous work has also shown that providing the daily feed allowance in three rather than two splits each day can also increase feed intake.

TABLE 1: Effect of treatment on lactation feed intake (Experiment 1).

	A	B	C	s.e.
Lactation feed intake (MJ/day)				
Week 1	44.3 ^b	52.1 ^a	50.1 ^a	1.73
Week 2	75.6 ^b	85.9 ^a	82.5 ^a	2.19
Week 3	92.9 ^b	100.7 ^a	104.5 ^a	2.03
Week 4	100.4 ^b	110.9 ^a	110.8 ^a	2.69
Weeks 1 to 4	77.5 ^b	87.6 ^a	86.6 ^a	1.13
Mean lactation intake (kg)	5.5 ^b	6.2 ^a	6.1 ^a	0.08

^{ab} Means in a row with different subscripts are significantly different ($P < 0.05$).

TABLE 3: Results from *ad libitum* dry feeders at Moorepark.

Daily feed intake (kg/day)	
Week 1	3.8
Week 2	6.7
Week 3	7.7
Week 4	9.8
Lactation mean	6.8
Weaning to service	4.0
Piglet performance	
Number born alive/litter	12.3
Number of pigs weaned/litter	10.4
ADG birth to weaning (g/day)	217.0
Weaning to service interval (days)	5.4
Sow lactation weight change (kg)	-1.1

Dry feeding

At the Teagasc Pig Conference in 2006, we presented a paper on litter size and how it is affected by sow feed intake during lactation. The advantage of *ad libitum* wet-dry feeders for sows was discussed as part of that presentation. Since then we have installed *ad libitum* hoppers into our existing troughs with in-built nipple drinkers in the farrowing rooms at Moorepark.

We have completed a trial involving 200 sows using these feeders. The results are shown in **Table 3** and the *ad libitum* hoppers are doing an excellent job. They averaged an intake of 6.8kg per sow per day over a 26-day lactation period. Sows were lighter by only 1.1kg at weaning, compared with their empty weight after farrowing. In our experience such high intakes and reduced lactation weight losses are very difficult to achieve using predetermined feed curves (scale feeding) with either dry or liquid feeding.

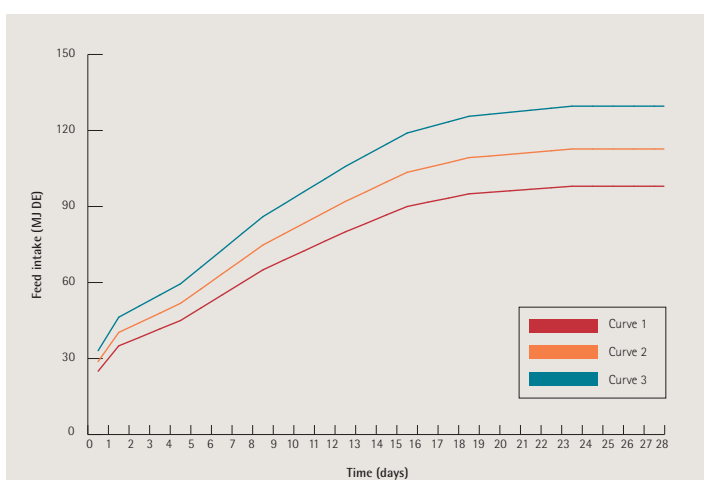
With the *ad libitum* hoppers we started sows on a feed allowance of 2kg on the day of farrowing and increased feed allowance to 4.5kg by day six of lactation. From day seven of lactation sows were given continuous free access to feed. As with all feeding systems, it was still important to monitor troughs. In this trial, troughs were inspected twice daily so that it was possible to prevent wastage early and to minimise the period of time that a sow was without feed in the event of a feeder blockage.

Ad libitum feeding for sows during lactation has proven to be a low cost but very effective method of increasing feed intake in this critical period. The

TABLE 2: Effect of treatment on lactation feed intake (Experiment 2).

	A	B	C	s.e.
Lactation feed intake (MJ/day)				
Week 1	47.8 ^a	65.8 ^c	57.0 ^b	2.01
Week 2	79.4 ^a	102.6 ^b	100.1 ^b	3.17
Week 3	99.4 ^a	126.9 ^a	122.8 ^b	3.40
Week 4	103.1 ^a	128.9 ^b	132.0 ^b	4.07
Weeks 1 to 4	82.3 ^a	104.9 ^b	105.1 ^b	2.36
Mean lactation intake (kg)	5.8 ^a	7.4 ^a	7.4 ^b	0.17
Weaning oestrus feed intake (MJ/day)	53.4 ^a	55.5 ^{ab}	56.7 ^b	0.92

^{ab} Means in a row with different subscripts are significantly different ($P < 0.05$).

**FIGURE 1: Lactation feed curves for liquid feed experiments (MJDE/day).**

technology is very simple and it does away with the necessity to use feed curves. After the first week of lactation, sows are simply allowed to satisfy their individual feed requirements. The message seems to be that the sow can do this more effectively than we can and without the complicated feed curves and expensive computers.

Whether a producer uses dry or liquid feeding, it is likely that sow feed intake can be greatly increased. Producers using liquid feeding should look to their feed curves. If you seldom have to minus individual sows from the curve then it is a good guess that the majority of your sows are underfed; no single curve can match the intake capacity of each individual sow. With liquid feeding you must be prepared to make regular curve interventions.

For dry feeders the advice is simple. Using *ad libitum* dry or wet-dry feeders for sows will greatly increase feed intake compared to scale feeding.



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Final instar larvae of *Paropsisterna gloriosa*.Adults of *Paropsisterna gloriosa*.

Herbivore hitchhikers

A newly introduced species of beetle recently threatened Irish *Eucalyptus* plantations. FINBARR HORGAN reports on how early identification of the beetle and intervention in its spread have been effective in reducing losses to Ireland's expanding cut foliage trade.

In August 2007, producers of *Eucalyptus* foliage for a cut foliage trade that is worth €4 million to the South West noticed moderate to severe dieback in some plantations. Dieback was restricted to Kerry and mainly affected green foliage species, particularly *Eucalyptus parvifolia*. Associated with this damage were dull green beetle larvae and brightly coloured adult beetles. Because damage was limited to eucalypts, which originate from Australia, it was evident that this was a newly introduced beetle, also of Australian origin. As autumn progressed, damage increased and the extent of the outbreak became apparent. By September, there was insufficient foliage on many trees for successful harvest. The extent of the damage, the rapid build-up of beetle numbers, and the importance of *Eucalyptus* trees in Ireland and Europe (over one million hectares planted on the Iberian Peninsula alone) required a swift response from the relevant authorities. Research at Teagasc Oak Park began immediately with three main objectives:

1. to identify the beetle, document its distribution, and determine its mode of spread;
2. to investigate the feeding and egg-laying behaviour of the beetle and thereby identify susceptible and resistant host species; and,
3. to develop and instigate a beetle management strategy (in co-ordination with growers and the Department of Agriculture, Fisheries and Food) with a view to possible eradication.

Australian hitchhiker comes ashore

Adult beetles collected in Killarney were examined by Dr Chris Reid of the Australian Museum in Sydney. Dr Reid, a leading expert on Australian Chrysomelid beetles, also examined specimens of an exotic beetle that was causing damage to forest eucalypts in Tasmania. The Irish and Tasmanian specimens were of the same species, a beetle called *Paropsisterna gloriosa* (*P. gloriosa*; Blackburn) that is native to the Blue Mountains of New South Wales, Australia. Somehow, live beetles had travelled half way across the world to survive and reproduce in Ireland. The species is not known to occur anywhere else; however, some closely related species are problematic on eucalypts in New Zealand, Southern Africa and the United States. Interceptions by quarantine officers in Britain indicate that adult and larval Chrysomelid beetles sometimes arrive on imported horticultural material such as tree ferns and other garden ornamentals.

Based on damage levels and beetle densities, the initial site of introduction to Ireland appears to have been near Kilgarvan in Kerry. By recording damage levels at all foliage plantations, Coillte eucalypt plantations and groups of garden eucalypts, and by mapping trade relations between foliage producers, research at Teagasc has been able to identify 'hitchhiking' as a key factor behind the spread of the beetle (**Figure 1**). Plantations that contracted the same foliage pickers were most susceptible to contamination by the beetle.



Eucalyptus cordata is highly resistant to *Paropsisterna gloriosa*.



Eucalyptus stand at John F. Kennedy Arboretum. *Paropsisterna gloriosa* will feed on a range of forestry eucalypts.

Adult beetles respond to danger, including the presence of humans, by gliding to the ground and hiding among leaf litter and ground mosses. However, where densities are high, inevitably some beetles become concealed in clothing and equipment. These are then easily transported the long distances between plantation sites. A gradual overland spread, using ornamental eucalypts as stepping stones, is not consistent with the current distribution patterns (although beetles and damage have been identified in Kerry garden eucalypts).

A generalist eucalypt feeder

In Kerry, *P. gloriosa* overwinters in the adult stage. By late March adults begin to emerge and lay eggs, but adults only place their eggs where their larvae will have the best opportunities for survival. Whereas the adults can feed on the tough gummy leaves of a range of eucalypts, their newly hatched larvae are restricted to new, expanding foliage, which is considerably softer. Research at Teagasc has shown that adults place their eggs on fully expanded, tough leaves, immediately adjacent to expanding foliage. Because the adults themselves prefer soft foliage, this strategy may help to avoid cannibalism of the eggs. Among the foliage eucalypt species, we found *E. glaucescens* as the favoured host (Figure 2). Survival and pupal weights are highest and development times are significantly shorter on this host than on most other species. Overall, *E. parvifolia*, *E. perriniana* and *E. moorei* were also generally suitable hosts. However, survival, feeding and egg laying were generally low on *E. pulverulenta* and *E. cordata*. This is reflected at plantations where both these species are largely undamaged by the beetle (Table 1). Furthermore, in plantations, eggs have been found on all foliage species except *E. pulverulenta* and *E. cordata*. A number of forestry eucalypt species were also examined at the horticultural entomology laboratory at Oak Park as potential hosts for the beetle. Adult *P. gloriosa* fed on all eucalyptus species tested, including *E. globulus*, *E. viminalis*, *E. muelleri*, *E. gunnii*, *E. urnigera* and *E. nitens*, indicating that the species will

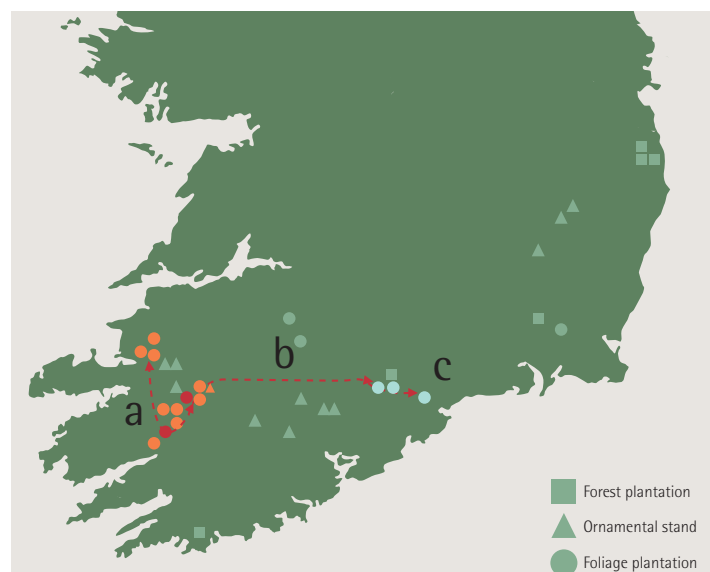


FIGURE 1: Distribution and spread of *Paropsisterna gloriosa*. a) Beetles have hitchhiked between plantation sites in Kerry but are largely absent from ornamental eucalypts. b) beetles may also have hitchhiked from Kerry to Waterford plantations, and, c) between Waterford plantations; however, damage in 2007 was low and the beetles appear to have been eradicated. There is no evidence of damage to Coillte eucalypt forestry sites or eucalypt foliage plantations in Limerick and Wexford. Key to symbols: red = presumed outbreak centre; orange = beetle present; blue = evidence of damage but no evidence of beetle, presumably eradicated; green = no evidence of infestation.

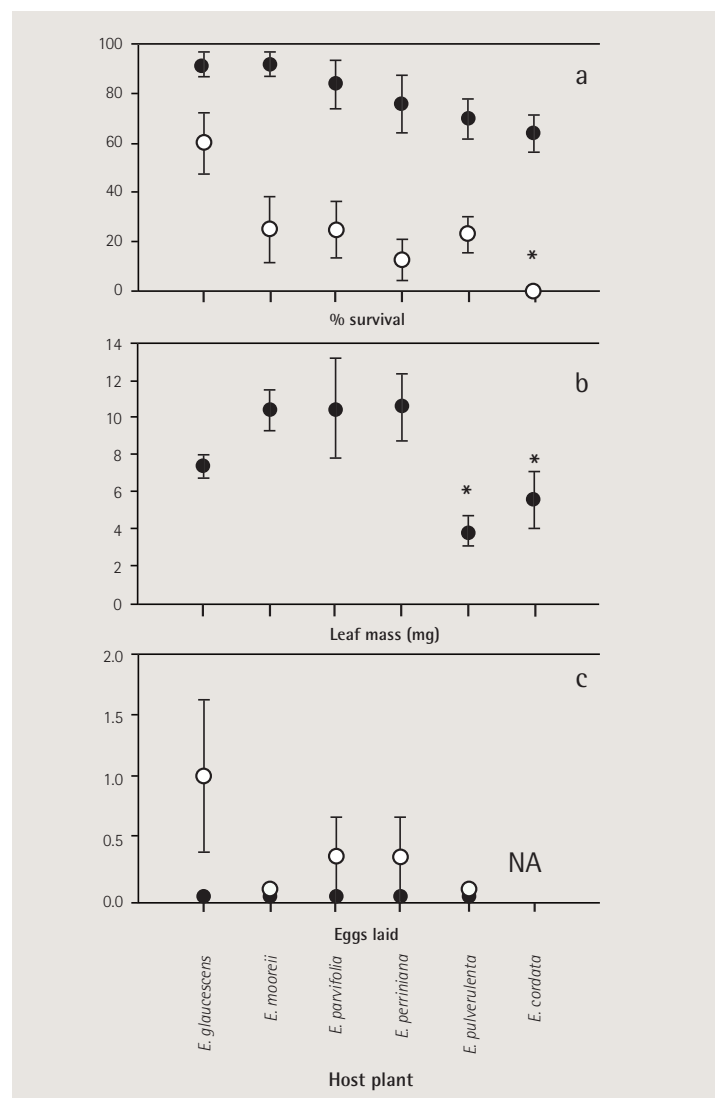


FIGURE 2: Results from laboratory studies of the quality of six eucalypt species as hosts for *Paropsisterna gloriosa*: a) five-day larval survival (solid circles) and survival to adult (open circles); b) leaf mass consumed during first five days; and, c) eggs laid on fully expanded (solid circles) and expanding (open circles) foliage during a choice experiment. NA = data not available; bars are standard errors; * = significantly lower fitness.

TABLE 1: Percentage of foliage removed by adult and larval *Paropsisterna gloriosa* from top and lower branches of foliage eucalypts at two Kerry plantations in 2007, indicating the general resistance of *E. pulverulenta* and *E. cordata*.

Site	Host plant	Top branches	Lower branches
Killarney	<i>E. parvifolia</i>	30	5
	<i>E. glaucescens</i>	29	1
	<i>E. perriniana</i>	19	0
	<i>E. moorei</i>	9	0
	<i>E. pulverulenta</i>	0	0
Mallow Road	<i>E. glaucescens</i>	4	0
	<i>E. cordata</i>	0	0

readily feed on the main forestry eucalypt species. This represents a potential threat to eucalypt forests in Ireland. Feeding continues through the summer and most larvae pupate in August and September. It is still unclear whether there are one or two generations a year.

Tools for management

Because *P. gloriosa* is an introduced species, it has few natural enemies. During our research, no parasitoids or beetle diseases were observed. Birds will glean the larvae from trees, but the impact of birds on beetle populations is likely to be low. Aided by life history data supplied by Teagasc, some growers have resorted to cultural and chemical methods to manage the beetle. By cutting back foliage in early spring, growers remove the young tender leaves that are required by developing larvae, thereby considerably reducing larval populations. Accurate and timely pesticide applications reduce adult numbers; however, as adults continue to lay eggs throughout the growing season, there may be a need for repeated applications. Growers that monitor their eucalypt plots for damage, and respond accordingly, will avoid unnecessary pesticide applications. Furthermore, growers who specialise in producing *E. pulverulenta* (a popular aromatic eucalypt), *E. cordata*, or other resistant species, will avoid problems caused by this beetle.

At Teagasc, we believe that the key to managing this exotic beetle is to avoid its further spread. Awareness among eucalypt plantation workers of the beetle problem and of its hitchhiker mode of spread is essential to curtail further damage. Teagasc, through its advisory network, is encouraging eucalypt workers to adhere to simple hygiene protocols; for example, clothing and equipment should be examined and beetles removed before leaving a plantation (preferably clothing should be changed when moving from one plantation to the next), and vehicle doors and windows should be kept closed when stationary at plantation sites.

Awareness of the presence of this new exotic beetle has helped growers to successfully manage *P. gloriosa* during 2008. The beetle now occurs only at very low densities in some commercial foliage plantations, many abandoned eucalypt plots have been cut down and removed, and some growers regularly monitor and treat their eucalypt crop to safeguard against establishment of the beetle. Nevertheless, the small pockets of beetles that still occur in Kerry will need careful and continued monitoring and the efforts to eradicate this newly arrived exotic beetle must be maintained.

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Some like it cool

Researchers at the Dublin Institute of Technology and Teagasc are involved in a project studying mushroom quality and product variability during storage.

Mushrooms have a shelf life of three to four days at room temperature, which is short in comparison to most vegetables. This is mostly because mushrooms are fungi and lack the outer protective cuticle that protects vegetables from physical and microbial damage, as well as water loss. As mushrooms have a high water content and no cuticle, it makes them prone to microbial spoilage, as well as bruising and enzymatic browning. A team of researchers at Dublin Institute of Technology (DIT) and Teagasc has been studying the effects of post-harvest storage conditions on the quality of the cultivated white mushroom, *Agaricus bisporus*.

Cool and moist

During storage, mushroom quality becomes dependent on environmental factors such as temperature, relative humidity and the gaseous composition of the storage atmosphere. The main processes that contribute to a reduction in quality after harvest are discolouration, browning, cap opening, weight loss and changes in texture.

A series of experiments were carried out to study the effect of temperature and relative humidity (RH) during storage on mushroom quality. Mushroom colour characteristics were measured (L^* value for whiteness, a^* value for brownness and b^* value for yellowness) to record any changes in colour during the storage time. Measurements of mushroom water activity, weight loss and turgor were also recorded as an indication of changes in the firmness of the mushroom. The experimental data were then modelled using mixed effect models in order to estimate the variability components.

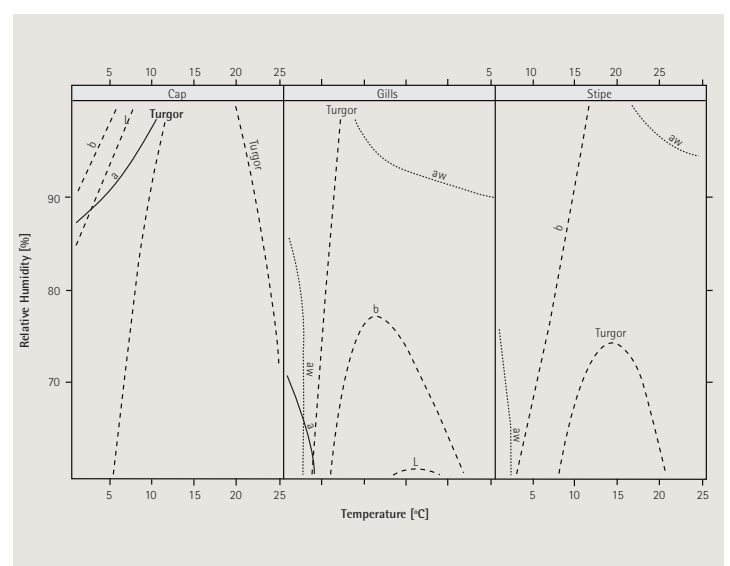


FIGURE 1: Best storage conditions for minimum quality changes in L^* value, a^* value, b^* value, water activity, turgor potential and weight loss for each tissue of the mushroom (cap, gills and stipe). The figure shows that in order to keep most of the quality parameters in the cap unchanged, low temperatures (below 5°C) and high RH (up to 90%) are necessary. In the case of the gills and the stipe, an optimal condition to keep the parameters unchanged was not found.



FIGURE 2: Image analysis set-up at DIT to observe whiteness reduction and the appearance of browning. The system is inserted inside an incubator with temperature and RH control.

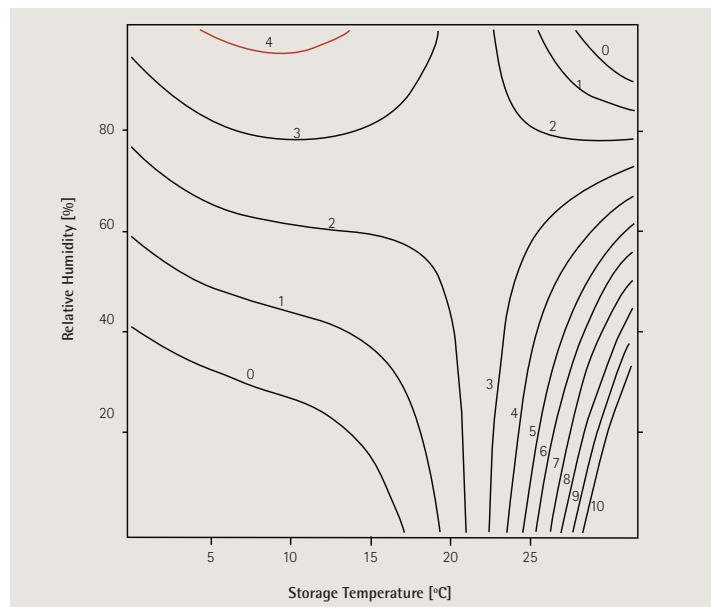


FIGURE 3: Contour plot showing the time taken in days for mushrooms to change from "white" to "brown" as a function of storage temperature and relative humidity. Optimum storage conditions are circled in red. At 25°C and RH <40 the mushrooms remain white for longer but they are dried out and of unacceptable quality. Numbers within the graphs refer to days.

Figure 1 indicates that the best storage conditions to minimise colour changes and turgor values for mushroom caps are low temperatures (below to 5°C) and high RH (up to 90%). This means that in order to maximise the shelf life, mushrooms should be refrigerated as well as packaged in some way to maintain a high RH within the package. A controlled RH storage chamber or a gas-permeable packaging material would be desirable to allow some release of respiratory gases and water vapour during storage, as otherwise there would be a depletion of oxygen and a build-up of condensation within the package, which could lead to microbial spoilage and browning of the produce.

Image analysis

With the advent of digital photography and computer vision systems, there is an opportunity to measure quality parameters such as colour changes in mushrooms, over time and under different conditions, and to follow these properties – even in retail situations.

Image analysis was used to measure the loss of whiteness and the appearance of brown discolouration of mushrooms during storage (Figure 2). A contour plot, tracking the time taken for mushrooms to change from "white" to

"brown", indicates the dependence of this transition time (Figure 3) on temperature and RH. The experiments proved that low temperatures (approximately 4–13°C) and RH close to saturation were necessary to keep mushrooms white for four days. The contour plot also showed that if the temperature was between 0 and 18°C and RH was higher than 80% then whiteness could be maintained for three days. The use of higher display temperatures would imply important savings of energy for retailers. However, it was found that if mushrooms were retailed at those high temperatures, after three days the whiteness decrease would occur very rapidly and would reduce the shelf-life of the product in the consumer's home.

Heavy breathers!

Fresh products, stored or packaged, remain metabolically active, consuming oxygen (O₂) and producing carbon dioxide (CO₂) and water as a result of their respiratory metabolism. Respiration rate, measured as O₂ consumption or CO₂ production, is a good indicator of the potential shelf life of fresh and minimally processed products, as the higher the respiration rate the faster the physiological ageing processes and senescence. Experiments were conducted to study the effect of storage temperature on the respiration rate of mushrooms in closed containers (Figure 4). Results showed that the variability between batches was quite



Figure 4. Closed system respirator with an O₂ and CO₂ analyser.

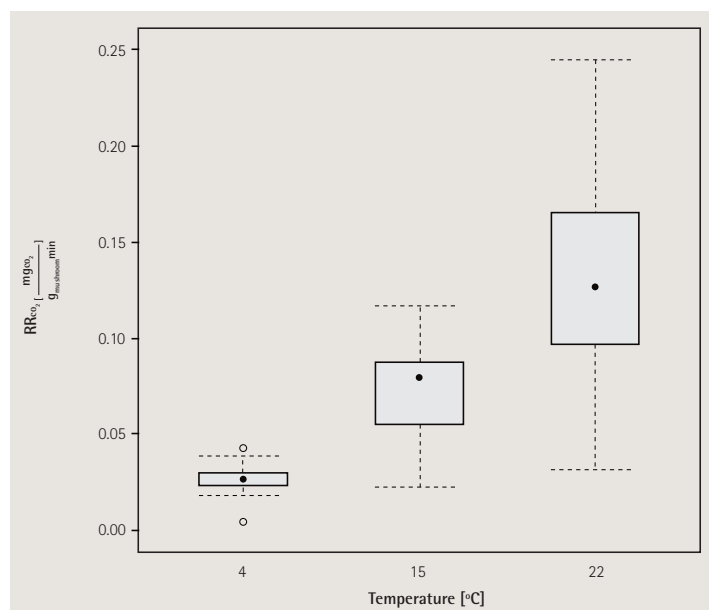


Figure 5. Respiration rate of mushrooms at different temperatures. Variability is much greater at higher temperatures.

high but it was much less for mushrooms stored at 4°C (Figure 5). This means that decreasing the storage temperature should increase the uniformity of the product. In this way retailers should use the lowest temperature available, not only to improve the keeping quality of the product but also to minimise the variability.

New technologies for measuring quality

Finally, new technologies such as metabolic profiling and hyper spectral imaging, are being examined as tools to better understand and characterise the process of senescence and quality deterioration in mushrooms. Preliminary work has been done looking at metabolic profiles in 55 samples of harvested mushrooms. A total of 32 metabolites have been identified, which includes six sugars and polyalcohols, 15 fatty acids and 11 phenolic compounds.

Hyperspectral imaging is another digital imaging system that can pick up differences in cap characteristics that are not visible to the naked eye. Both these techniques will be used in future projects to characterise quality changes in mushrooms due to factors other than post harvest and storage, such as the presence of an undesirable pathogen.

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Seed loss from oilseed rape

Seed loss from harvesting oilseed rape results in lower yields and also causes rape to appear as a volunteer weed in subsequent crops. PAUL FLANAGAN and DR EWEN MULLINS at Teagasc Crops Research Centre, Oak Park, explain the case for developing varieties with a lower potential for seed loss.



The popularity of oilseed rape (*Brassica napus*) has increased among farmers over the last few years, with over 8,000ha sown in 2008, mainly because of the development of novel market outlets encompassing increased global demand for both cooking oil and biodiesel. Extracted from the harvested seeds, oilseed rape oil can be incorporated into lubricants for petrol engines, and extracted methyl esters can be used as a diesel substitute. Introduced as a break crop in cereal rotations, it has been shown that oilseed rape will boost subsequent cereal yields versus the option of continuous cereal tillage.

For Irish farmers, yields of approximately 3–3.5t/ha for winter rape and 2.5t/ha for spring rape are required to make the crop economically viable. Attaining these target yields requires intensive management of a crop that is sensitive to competition from broad-leaf and grass weeds such as volunteer (plant that grows in crop that was not intentionally planted) cereals and wild oats, which can depress the crop's yield potential, and that also has a propensity to shed its seed pre-harvest. The latter arises due to the asynchronous nature in which oilseed rape pods mature, with those at the apex of the plant canopy maturing last, which increases the potential for premature pod shatter and, ultimately, seed loss, during harvest operations. The issue is compounded further as 'lost' seed that enters the soil will be induced into secondary dormancy, only serving to promote oilseed rape as a volunteer weed in the cereal crops that follow. On the tillage farm of today, maximising profits is of key concern; hence, excessive seed losses during harvest operations will curtail profit margins. But how much seed can be lost?

This research highlights the importance of developing oilseed rape varieties with a decreased potential for asynchronous pod shatter.

Oak Park study

Eleven commercial oilseed rape systems were surveyed for seed loss in 2006 and 2007, by placing trays under the crop canopy to catch seeds lost as the harvester passed over. Seed loss was recorded outside the front wheels of the harvester yet under the header, and also directly beneath the harvester between the wheels.

Seed losses recorded ranged from 59kg/ha (Site D, 2006) to 533kg/ha (Site A, 2007). If we consider the average yield of 3t/ha, this equates to 1.9% to 17.76%, respectively, of potential yield.

Not surprisingly, across all sites examined in 2006 and 2007, a greater proportion of seed was lost directly beneath the harvester, as opposed to under the header but outside the wheels of the harvester. It is estimated that the loss of seed can reach up to 10,000 seeds/m² on the soil surface, which, in turn, leads to the contamination of subsequent crops by the resulting volunteer plants. Seed losses presented in this study ranged from



Volunteer oilseed rape plants (yellow flowers) in a subsequent crop of winter oats.

approximately 1,100 seeds/m² to over 12,000 seeds/m², with an overall mean of 4,106 seeds/m². Subsequent visits to each site recorded an average of only 53% of lost seed emerging as volunteers prior to the sowing of the next cereal crop, implying that the post-harvest treatments adopted at each site were not maximising the potential for lost seed to germinate.

Indeed, encouraging the germination of lost seed prior to sowing the following cereal crop is key to controlling the emergence of volunteers, which will emerge through the rotation (illustrated in photo) and can continue to appear for up to 10 years after sowing the initial oilseed rape crop. Based on field trials completed at Oak Park in 2007 and 2008, leaving the land fallow for four weeks after harvesting the oilseed crop will maximise the rate of volunteer emergence, which we have recorded at up to 100 plants/m². The single most effective treatment to control this volunteer population is through the application of a broad-spectrum herbicide five weeks post harvest. In contrast, lightly tilling the soil will induce a second 'flush' of volunteers but will not exert the level of volunteer control required and, most significantly, serves to facilitate the transfer of seed into the soil bank where it will remain dormant and emerge as volunteer weeds. Our results indicate that there should be no mechanical disturbance of the soil for up to 10 weeks after harvest if possible, thereby maximising the germination potential of seed lost during harvest.

Climatic factors

It is accepted that climatic conditions before and during harvest play a critical

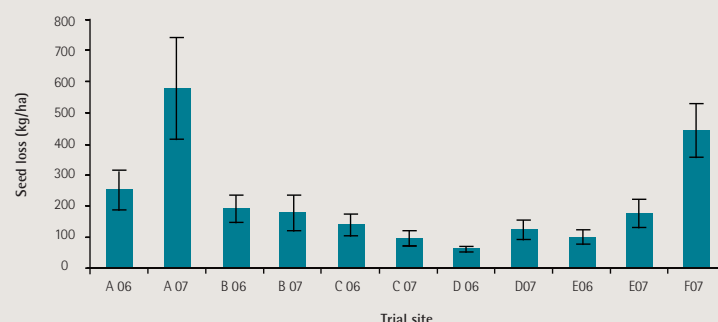


FIGURE 1: Seed lost from oilseed rape (kg/ha) during harvest.

role in the rate of seed loss. Indeed, harvest conditions in 2007 were poor, which partly explains the range of seed loss (3.1% up to 17.76%). However, conditions in 2006 were considered to be 'ideal' for harvesting oilseed rape, but seed losses of up to 8.3% of potential harvest were still recorded. Although some of this loss could be offset by optimising combine settings during harvesting, this research highlights the importance of developing oilseed rape varieties with a decreased potential for asynchronous pod shatter. Furthermore, taking into account the possibility that GM oilseed rape varieties could be available to Irish farmers in the near future, the issue of exerting greater control over seed loss is all the more critical, in order to ensure the efficient segregation of GM and non-GM oilseed rape systems.

This research was funded by the Teagasc Core Programme.

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Supporting Irish food SMEs

PAT DALY, Head of Food Training & Technical Services, explains how Teagasc AFRC supports the development of Irish food SMEs through training and innovation services.



Attendees at a food training course at AFRC.



The new training facilities at AFRC.

Small- to medium-sized food businesses (SMEs) make up over 90% of the approximately 700 food manufacturing companies in Ireland. Similar percentage figures prevail in many other European countries. These small food companies are located in every county in Ireland and contribute enormously to the local and regional economy, both in terms of employment and as a key customer and supplier link in the indigenous food supply chain. The ability to produce a stream of new products to meet consumer demands is often recognised as a critical success factor for Irish food companies. There has been substantial investment at national level in recent years into food research programmes and company development initiatives. More technically advanced companies with appropriate R&D capabilities can access research results. However, there remain significant challenges for many food companies, in particular for SMEs, who often lack the in-house technology/R&D capability to develop new products, understand marketplace requirements and, in particular, learn how to access new knowledge that can be used to their competitive advantage. Teagasc, in its recent Foresight 2030 report, recognises the challenges facing food SMEs and is developing an expanded SME technology support service to help these companies to innovate.

Specialist training and R&D support

Teagasc Ashtown Food Research Centre (AFRC) in Dublin has two decades of experience in providing specialist technical training and support services for the food sector in Ireland. Now, through the combined expertise and facilities of AFRC and Moorepark Food Research Centre (MFRC) in Cork, a comprehensive technology support programme is available to industry. Our trainers are unique in that they are highly qualified both as scientists and as trainers, and they work from within an applied food research environment. Trainers act as technical

consultants to industry and are actively involved in the development of national food standards and policy documents on training. This gives trainers very practical experience of food standards, production practices and policy developments in the food industry.

Our trainers are unique in that they are highly qualified both as scientists and as trainers and they work from within an applied food research environment.

Symbiotic relationship

Training is provided as one element of a technology support service to industry. Other inter-related supports are: access to modern food processing facilities; specialist in-company consultancy; a technical information service; and, marketing/business planning supports. This industry support team is backed up by the expertise and project outputs from the food research programmes at Teagasc. Conversely, this connection between research and industry programmes provides the opportunity for researchers to maintain close contact with food sector technology needs. A range of training courses is provided in food safety, food quality and technology and product development. External expertise is availed of where necessary, such as from Leatherhead Food International (UK), which is a recognised leader in international food legislation and new product development training.



A range of training courses is provided in food safety, food quality, and technology and product development.

The majority of courses are aimed at management level and are typically attended by technical and production managers. Courses are typically of short duration (up to three days), and delivered over several weeks to accommodate people at work in the industry. Course-related project work is additional to this time. Courses are usually developed to address a particular knowledge or skills gap, such as interpretation of emerging legislation and food technical standards requirements. Courses are delivered at Teagasc centres or other centres around the country, but the majority of training is carried out in-company and customised to client needs. A variety of training initiatives has been carried out over the years to address specific industry needs, usually in conjunction with national or regional agencies such as FÁS, Enterprise Ireland and Leader Groups. Examples are the development of trainer training, conversion of courses into European languages, understanding food retailer technical requirements and validating food safety processes, to mention just a few. Selected courses have been developed into e-learning versions through the Teagasc e-College.

Innovation support

The innovation support for SMEs involves providing expertise in food technologies, new product development and advice on food production standards and premises. Food businesses have access to modern food processing facilities at AFRC for product development. These include a meat processing facility, a general purpose food processing plant, a cooked meat facility, a bakery and a test kitchen. Businesses may use a range of processing equipment at the centre or may bring their own equipment. Additionally, testing can be carried out connected to product development, such as for



Practical training workshop at AFRC.

microbiological and chemical standards, product shelf life and sensory testing. AFRC receives in the region of 1,300 enquiries every year. These are handled through approximately 100 training courses attended by participants from about 150 food businesses. About 60% of these are customised to fit client requirements. Consultancy and innovation supports are provided to approximately 150 companies each year. Food training and other industry services operate to best customer service standards. It is Teagasc policy to certify training provided through the National Qualifications Authority of Ireland (NQAI) qualifications framework. This ensures that participants and sponsoring companies can be assured of qualification recognitions and standards achieved. In addition, training and consultancy services are registered to ISO 9000 quality management standard and food processing facilities have Excellence Ireland Hygiene Mark status.



For further information on Teagasc food training courses please see www.teagasc.ie/ashtown, or contact **Pat Daly**, Head, Food Training and Technical Services, AFRC, Tel: 01 805 9538, E-mail: pat.daly@teagasc.ie, or **Margaret Hennessy**, Course Administrator, Tel: 01 805 9520, E-mail: margaret.hennessy@teagasc.ie.



Figure 1: Teagasc research officer Vivian Gee operating the new scanning electron microscope. Inset is an image of a fractured milk powder particle to show surface detail and internal aerated structure.

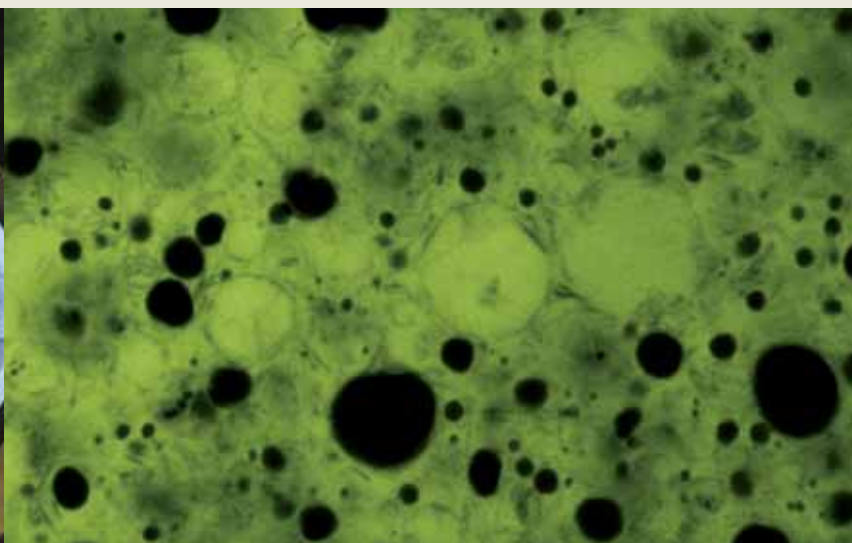


Figure 2: Confocal scanning laser micrograph of butter, showing water droplets (black) and fat crystals (dark rings).

The power of microscopy

The National Food Imaging Centre, Moorepark, is equipped with powerful new tools for studying food microstructure. DR MARK AUTY describes the range of equipment available to Irish food processors.

Introduction

The National Food Imaging Centre (NFIC) based at Moorepark is the first of its kind in Ireland and comprises a suite of state-of-the-art imaging tools specifically chosen for studying food microstructure. This new imaging equipment builds on existing microstructure expertise at Moorepark and complements indirect analytical techniques for characterising food structure such as rheology, laser scattering and various spectroscopic methods. The NFIC, jointly funded by the Department of Agriculture, Fisheries and Food and Teagasc, is now fully operational and provides a comprehensive range of light, confocal, electron and atomic force microscopes (Figure 1).

Why is food microstructure important?

The processability, texture, flavour and keeping qualities of food are controlled not just by chemical composition, but also by how the various ingredients are distributed and interact at the nanoscopic and microscopic length scales. Food structures vary enormously, from relatively homogenous liquids to complex, multiphase solids containing fats, proteins, polysaccharides, salts and water in the form of fibres, droplets, crystals, glasses or networks. The size, shape and

distribution of these structures greatly influence product stability, as well as sensory properties and even bioabsorption. Even an apparently homogeneous product such as butter owes its melt-in-the-mouth properties to the presence of ordered fat crystals (Figure 2). Microscopy techniques have the great benefit of directly visualising real foods, as opposed to using analytical techniques to measure them.

Who benefits?

The equipment is now available to support both the research community and the R&D activities of the Irish food industry. The primary functions of the NFIC are to:

- support and expand our understanding of food structure and functional properties;
- underpin new food nanotechnology and expanding biotechnology programmes;
- provide a centre of excellence that will enable Ireland to compete at an international level, in particular for EU Framework funds; and,
- provide expert analysis and consultancy for the Irish food industry.

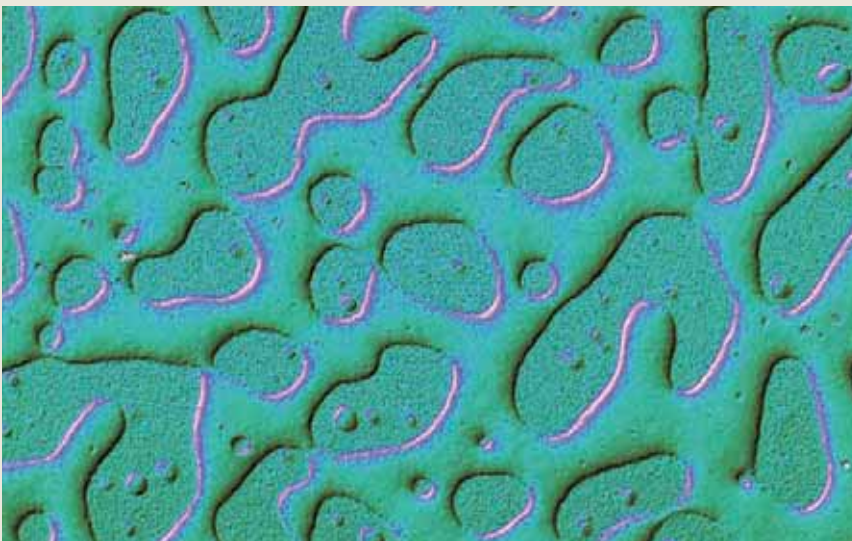


Figure 3: Protein/polysaccharide mixture showing two distinct phases. Differential contrast image light micrograph. Phase separation and emulsion instability are major issues for food processors.

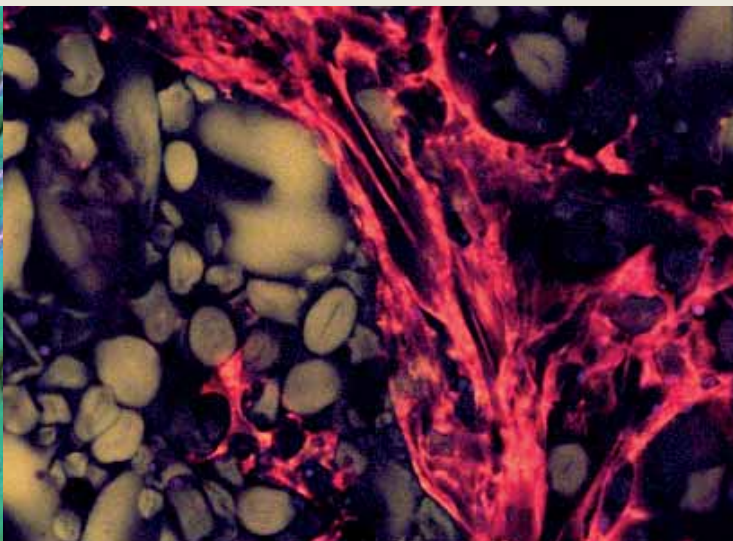


Figure 4: Confocal scanning laser micrograph of bread showing starch (brown), fat (purple dots) and gluten network (red). Multiple dyes enable simultaneous imaging of the different components.

Publicly-funded research

The NFIC is a key element of the recently launched Teagasc Vision programme and is currently integrated into two microstructure-based projects:

1. **Creaminess perception** (DAF Project RDTMFRC-422): Dynamic confocal microscopy shows how shear forces affect microstructure and release of fat in dairy products. Results will be related to rheological properties and full descriptive sensory analysis.

2. **Optimisation and characterisation of protein nano-fibrils** (DAF Project RDTMFRC-423): The formation, characterisation and functional properties of nano-fibrils derived from whey proteins are being studied by atomic force microscopy and electron microscopy.

In addition, microstructure plays an important role in characterising the functional properties of dairy products such as cheese, yoghurt and milk powders within many other projects, both at Moorepark and across Teagasc centres.

Benefits to industry

The new equipment strengthens the research and development capabilities of the Irish food industry by providing access to highly specialised microscopy techniques and expertise in food structure analysis. Any food or beverage product can be examined with minimal sample preparation. Typical applications include:

- powder characterisation – morphology, size, stickiness, surface features;
- emulsion stability – phase separation, protein aggregation, droplet sizing;
- microstructure of natural foods – fruit and vegetables, meat, fish;
- microstructure of processed foods – dairy, meat products, bakery, confectionary, spreads, etc; and,
- packaging materials.

The equipment

Light microscopy

Conventional light microscopy remains greatly underused by food scientists. Information on particle size, shape, air content, crystal form, and ingredient distribution is quickly obtained using the appropriate contrast technique and interpretive skills. Modern light microscopes are fitted with optical contrast techniques, such as differential interference contrast, to show phase separation behaviour in otherwise transparent liquids (**Figure 3**), while dyes can identify specific components such as fats, proteins or polysaccharides.

Confocal scanning laser microscopy

Confocal scanning laser microscopy (CSLM) is similar to epi-fluorescence microscopy, where a fluorescent dye is added to label the component of interest. General protein and fat dyes can reveal ingredient distributions in real products (**Figure 4**). A key feature of confocal microscopy is three-dimensional imaging of food structures. Additional features have been added to our microscope, including a micro-tensile testing stage for solid foods and a cryo-optical shearing stage for liquid/semi-solid foods. These attachments will facilitate the real-time study of food structures during shearing and tensile testing.

Electron microscopy

Light microscope resolution is limited to around 0.25 microns by the wavelength of light. An accelerated electron beam has a much smaller wavelength; consequently, much higher resolution is possible. The electron beam is focused by electromagnetic "lenses" and images are formed either by scanning the surface of a bulk sample such as in scanning electron microscopy (SEM), or by looking through a very thin sample as in transmitted electron microscopy (TEM).

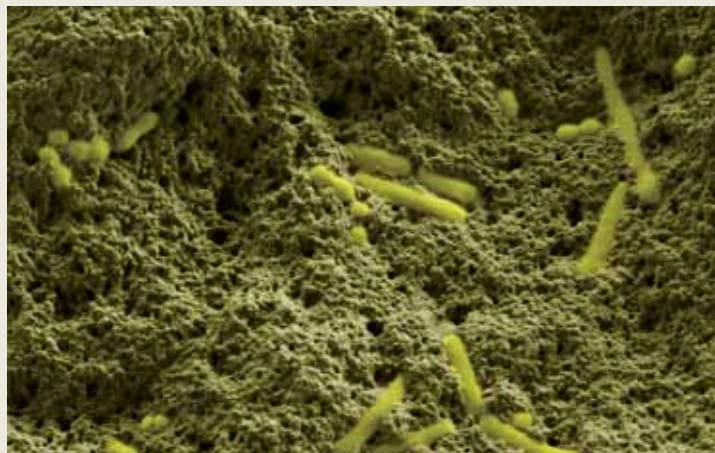


Figure 5: Cryo-scanning electron microscope image of yoghurt showing rod and cocci-shaped starter culture bacteria (yellow) embedded in a matrix of protein particles.

Traditionally, electron microscopy of food samples required extensive sample preparation involving chemical fixation, dehydration and possibly resin embedding. However, recent advances in the technology, in particular field emission electron optics, low-vacuum technology and cryo-preparation, mean that it is now possible to visualise 'difficult' food samples close to their natural state at a resolution of a few nanometers and with little or no sample preparation. These include liquids, frozen products and samples with high moisture, fat or sugar contents such as yoghurt (**Figure 5**), dairy spreads and ice cream. The newly commissioned SEM at Moorepark uses the latest field emission technology and is fitted with secondary, backscattered and transmitted electron detectors and, most importantly, the cryo-stage. An additional variable pressure mode allows examination of partially hydrated samples. The transmitted detector permits high resolution imaging of samples that have been prepared for TEM, such as ultra-thin resin sections or negatively stained food macromolecules.

Atomic force microscopy

Atomic force microscopy (AFM) is a completely new imaging technique for Teagasc researchers and provides fundamental data on the physicochemical properties of food materials, thus complementing SEM and CSLM data. AFM is very different from the other imaging techniques described above in that images are generated by moving a very small silicon nitride tip across the surface of the sample. The tip is attached to a cantilever, which deflects in response to minute surface variations in height. The deflection is converted to a brightness value that we see on the screen. This technique provides the highest possible imaging resolution of biological materials, permitting direct visualisation of individual biomolecules including lipids, proteins and polysaccharides, as well as microorganisms (**Figure 6**). A resolution of one nanometer has been achieved on biological samples such as DNA. A unique feature of AFM is its ability to characterise the mechanical properties of food

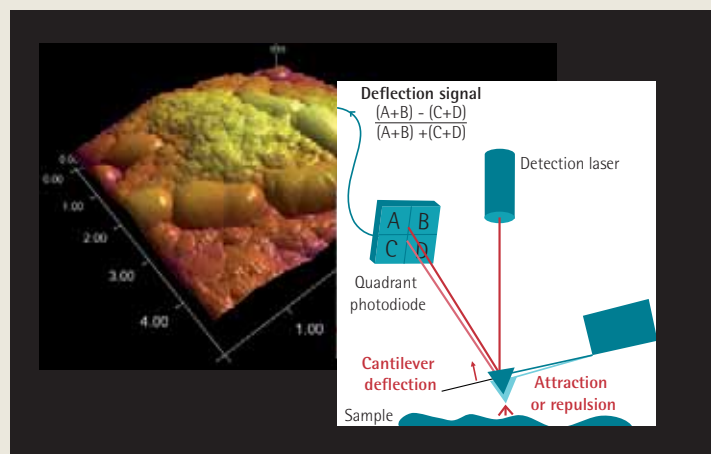


Figure 6: Atomic force microscope image of bacteria (*Lactobacilli*) embedded in whey protein gel. Inset shows the principle of the technique.

materials, including stiffness, elasticity, friction and stickiness, in addition to surface topography. Samples can be analysed under ambient conditions in liquid or gas environments, and over a wide range of temperatures.

Image analysis, management and reporting

Outputs from the various microscopes are all in the form of digital images and these can be quantified using a wide range of sophisticated image analysis software packages. Typical measurements would include particle size, phase volume, clustering or alignment. Image analysis data can then be correlated with other physical measurements and sensory data. Images, being the most valuable output from the various microscopes, are stored on a secure, fully networked, server-based image management system. By combining the outputs of the NFIC instrumentation with that of other analytical techniques in use in MFRC such as rheology, and particle and texture profiling, food technologists have a lot of powerful tools at their disposal with which to manipulate texture in novel foods or trouble-shoot stability problems in existing products.

The equipment was part-funded by the Department of Agriculture, Fisheries and Food under the National Development Plan 2007–2013 (Strategic Equipment Initiative). For further information and to arrange access to the equipment, please contact **Dr Mark Auty**, Moorepark Food Research Centre, Teagasc, Fermoy, Co. Cork, Tel: 025 42442, or E-mail: mark.auty@teagasc.ie.



Ensuring food safety – measuring residues

The National Food Residue Database is an invaluable resource for Irish consumers, researchers and authorities. Using it, and working with partners in other government agencies, Ashtown Food Research Centre is ensuring the safety of Irish food.

The safety of food for the consumer is of great importance and is challenged on an ongoing basis by a diverse range of possibilities – transmission of animal disease to humans (such as BSE in beef), microbiological contamination (such as *Salmonella agona* in cooked meat products), and chemical contamination (such as melamine in dairy powder products). In the case of chemical contamination, there are instances of potentially harmful chemical residues in food from a wide variety of sources. Serious examples of such chemical contamination are the following:

Illicit addition of chemicals to food – Melamine into milk in China to increase the milk's apparent protein concentration (2008); sale of adulterated cooking oil as olive oil in Spain ('Toxic Oil Syndrome') leading to 400 deaths (1981).

Industrial contamination – Dioxins from contaminated oil into animal feed, leading to contamination of dairy and meat foods in Belgium (1999); mercury dumped into Minimata Bay, Japan, leading to methylmercury in fish and neurological damage to humans (1960s).

Food processing contaminants – Acrylamide occurring during high temperature cooking of starchy foods, e.g., potato chips; polycyclic aromatic hydrocarbons (PAHs) occurring in grilled or charred meats.

Abuse of illicit drugs – Nitrofurans (banned antimicrobials) in fish, poultry and pork (2003); Clenbuterol (banned growth promoter) in beef liver in Spain, causing illness requiring hospitalisation (1990).

Apart from these examples, modern food production is undertaken using a wide variety of veterinary drugs (antimicrobial and antiparasitic drugs to protect and treat animals) and agrochemicals (pesticides to protect crops and animals, fertilizers) in order to produce sufficient food of good quality. Also, food production occurs in an environment where the animals and plants may be exposed to chemical contaminants such as mycotoxins, radionuclides, heavy metals, marine biotoxins, nitrates and various persistent organic pollutants.

On the positive side, the vast majority of the food consumed in Ireland is free of chemical contaminant residues at levels that might be of concern for human health. This high quality of the food supply is achieved by good food production and processing practices, in a clean environment, supported by national and European regulations designed to ensure food safety for the consumer. For example, regulations govern the use of veterinary drugs and

agrochemicals, including prohibiting the use of substances that may be potentially harmful to human health, specifying conditions of use for allowed substances, and establishing maximum residue levels that are permitted in food. Other regulations require testing of food for chemical contaminants through the various residue monitoring and surveillance programmes.

While it is extremely difficult to ensure total compliance with correct use of veterinary drugs and agrochemicals, and total avoidance of food contamination from environmental and industrial contaminants, the combination of regulations on use and systematic residue testing of foods gives a high level of protection to the consumer.

National Food Residue Database – concept and history

During the period 1995 to 2000, a major research project was undertaken at Ashtown Food Research Centre (AFRC) involving a broad range of residue studies in foods of animal origin (dairy, meat and fish products) for various veterinary drugs, pesticides and contaminants. The results of some 30 studies were published and provided very valuable information for the Irish food industry, regulatory agencies and others concerned with the production and marketing of Irish food.

In the latter years of the decade, a number of wide-reaching changes were occurring in Europe, relating to the issue of food safety. The scare in Britain in 1996, potentially linking BSE in cattle with the development of CJD in humans, led to a radical rethink on food safety in Europe, with the call for "establishment of a proper food policy, which gives pride of place to consumer protection and consumer health" (Commission President Jacques Santer, 1997). This call was responded to by the further development of DG SANCO, with responsibilities for scientific advice, risk analysis and control in the area of food. At a national level, the Food Safety Authority of Ireland (FSAI) was established in 1999, with the

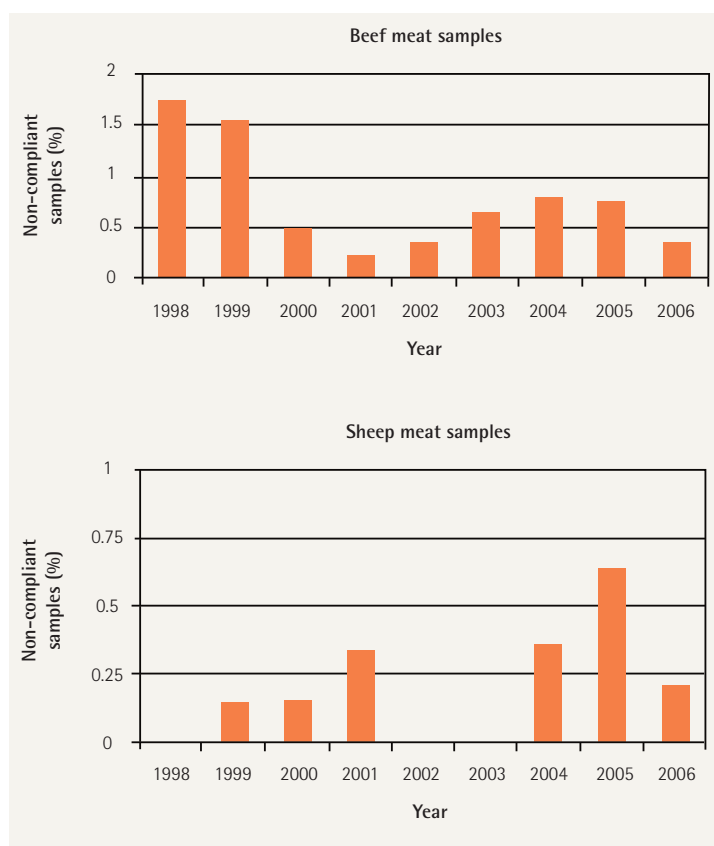


FIGURE 1: Occurrence of non-compliant samples (% of samples tested) for antimicrobials in beef and sheep meat over the period 1998 to 2006.

principal function of ensuring that food produced, distributed or marketed in Ireland should meet the highest standards of food safety and hygiene. Against this background, AFRC decided to establish the National Food Residue Database (NFRD) as a comprehensive database for chemical residues and contaminants in food in Ireland. The NFRD would be set up as an interactive website and would contain data from the residue studies research project at AFRC and from all the major residue monitoring and surveillance activities carried out by the various agencies in the country. The unique feature of the NFRD – matching the new openness on food safety issues and the central position of the consumer – was that it would be available to open access. After a number of years' development, the NFRD website was launched in 2005.

Using the NFRD

Residue data in the NFRD covers the period from 1995 to 2007, and is updated on a continuing basis. There are approximately 140 datasets in the NFRD, classified either as 'Monitoring Programmes' or as 'Studies and Surveys'. 'Monitoring Programmes' refer to the annual testing programmes for chemical contaminants, under national and EU regulations, undertaken, for example, on foods of animal origin and for pesticides in food. 'Studies and Surveys' refer to datasets from particular studies on chemical contaminants in food, such as may be carried out by the FSAI, the Environmental Protection Agency, the Radiological Protection Institute of Ireland, and Teagasc.

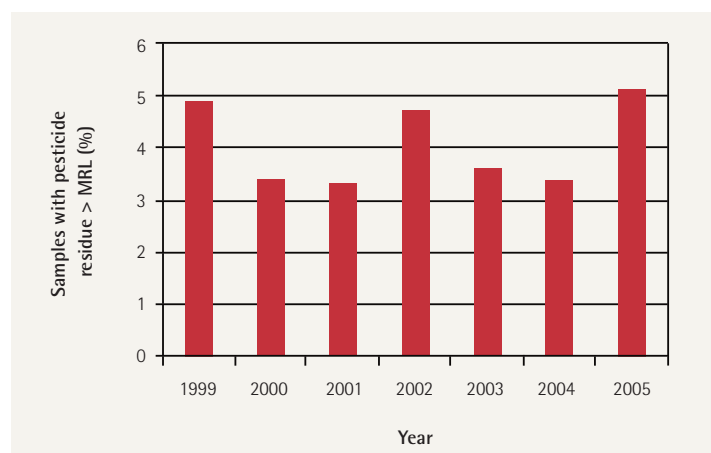


FIGURE 2: Samples of fruit and vegetables containing pesticide residues above MRL values during the period 1999 to 2005 (%).

TABLE 1: Dioxins and dioxin-like PCBs in market foods (pg WHO-TEQ/g fat).

Food	n	Mean		Minimum		Maximum	
		Dioxins	PCBs	Dioxins	PCBs	Dioxins	PCBs
Carcass fat	34	0.27	0.26	0.08	0.05	0.62	0.61
Dairy products	6	0.19	0.18	0.08	0.05	0.25	0.27
Liver	7	1.19	0.42	0.32	0.11	4.04	1.42

The scope of the datasets contained in the NFRD includes:

- veterinary drugs;
- pesticides;
- radioactive substances;
- environmental contaminants;
- processing contaminants;
- dioxins and polychlorinated biphenyls (PCBs);
- marine biotoxins;
- heavy metals;
- mycotoxins; and,
- nitrates.

Access to study results is made through 'Search Residue Database' on the website homepage. A search may be made through the following options: 'Study Year'; 'Study Type'; 'Food Type'; or, 'Residue Type'. The summary details for each study are presented on the 'Study Overview' page, from which detailed results may be presented in tabular format or summary results may be viewed by graphics. For 'Monitoring Programmes', results may be compared on a yearly basis; this allows the user to identify trends in the occurrence and/or levels of particular chemical residues over time. Further information and documents, such as regulations, residue limits, published reports, and related studies, may be accessed from the 'Study Overview' page, or directly from the website homepage by selecting 'Search Document Library'.



The NFRD website homepage.

What is the situation with regard to chemical residues in Irish food?

A major body of data on the NFRD is from the annual testing of foods of animal origin (meat, dairy, eggs, fish, etc.) for a wide range of residues, as required by Council Directive 96/23/EC. The results from this annual monitoring programme of Irish food indicate that, for most categories of chemical substances tested, no detectable residues or residues at levels below the specified limits are found. One exception to this generally satisfactory situation is the case of residues of the anticoccidial drug nicarbazin in poultry liver, where relatively high numbers of samples are found to contain nicarbazin above the specified limit of 200 µg/kg (ppb). Considerable work on this problem has been undertaken through joint research projects by AFRC and Queen's University, Belfast, leading to a reduction in the incidence of non-compliant samples from approximately 20% (2004) to 7% (2007). The other area of veterinary drugs where non-compliant samples may be found is that of antimicrobials; trends for the incidence of samples non-compliant for antimicrobials in various food types are shown in **Figure 1**.

Another area of interest is dioxins and PCBs in various foods, and a number of studies have been carried out in recent times. One such study on levels of dioxins and PCBs in Irish food, organised by the FSAI in 2003, showed that no measurable residues of dioxins and PCBs were found in fruit and vegetables. In foods of animal origin, the highest levels were found in liver samples, with up to 5.5 pg WHO-TEQ/g fat being determined for dioxins and PCBs combined (**Table 1**); this is below the maximum level specified by the EU of 12 pg WHO-TEQ/g fat for dioxins and PCBs combined.

The monitoring programme for pesticides involves annual testing of foods for pesticides and their metabolites. No pesticide residues are detected in approximately half of the samples of fruit and vegetables tested each year. The proportion of samples containing residues exceeding the relevant maximum residue levels (MRLs) ranges from 3 to 5% of samples each year (**Figure 2**). The Pesticide Control Service, Department of Agriculture, Fisheries and Food,



Image courtesy of Bord Bia

The high quality of the Irish food supply is achieved by good food production and processing practices, in a clean environment, supported by national and European regulations designed to ensure food safety for the consumer.

undertakes a risk assessment on all cases where MRLs are exceeded, and has found that, in general, these do not constitute a major concern for human health, occurring typically as isolated incidences and/or resulting in an intake of pesticide in the diet that is considerably lower than the acceptable daily intake (ADI) for such pesticides.

Overall, the situation regarding chemical residues in Irish foods appears to be good and the testing programmes and other regulations are in place to maintain and improve the situation. However, constant vigilance is required to ensure that Irish consumers are not exposed to harmful residues in food, particularly from unexpected sources or practices. Together with the body of regulations and residue testing programmes, the NFRD is a very important tool for providing data on food safety and for tracking trends in chemical residues in food.

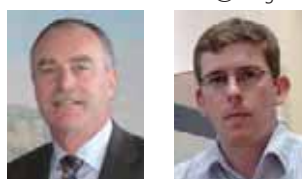
Acknowledgement

The NFRD project is part-funded by grant aid from the Food Institutional Research Measure (FIRM), which is administered by the Department of Agriculture, Fisheries and Food. It is co-ordinated by Ashtown Food Research Centre. The NFRD website can be accessed at: <http://nfrd.teagasc.ie>.

Dr Michael O'Keeffe (recently retired from Teagasc, AFRC) developed the National Food Residue Database (NFRD) in 1998 and managed it until 2008.

Dr Martin Danaher is the current lead researcher in chemical contaminants at AFRC and the current project manager of the NFRD.

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The role of dung beetles in grazed landscapes

Control of parasites has greatly benefited animal production, but chemicals such as ivermectin have long been implicated in negative effects on dung decomposition and on farmland wildlife. NORMA O'HEA, PAUL GILLER and JOHN FINN describe the role of dung beetles in dung decomposition. This research directly measures the effects of ivermectin on dung beetles, but also indicates how to better select anti-parasitic chemicals that minimise unintended environmental effects.

Inhabiting the hidden world of the dung pat, the activities of dung beetles are rarely observed. Yet they play an important role in dung decomposition and nutrient cycling, and provide a crucial food source for many species of farmland wildlife. Their importance for dung decomposition was highlighted following the colonisation of Australia. Along with the European settlers came a large number of cattle – and cattle dung. Very soon, pastures were covered with dung, with dung pats taking up to four years to decompose. Because the native Australian dung beetle fauna were not adapted to remove dung from introduced non-native livestock such as cattle and sheep, a major dung beetle introduction programme had to be initiated. Dung beetle species from Europe and Africa were introduced to Australia in the 1960s and have successfully reduced pasture fouling and dung-breeding pests.

This article describes the important role of dung beetles in contributing to dung decomposition in north temperate areas, including Ireland. There has been a lot of discussion about the possible impacts of ivermectin use on dung decomposition via toxic effects on dung beetles. In areas with wildlife species of high conservation value that feed on dung beetles, ivermectin use is often severely limited under wildlife management agreements in protected areas. Surprisingly, there is relatively little direct evidence on the toxic effects of ivermectin for north temperate dung beetles, and this article describes an investigation of this issue.

Life cycle of dung beetles

Dung beetles represent a large faunal group within dung pats. North temperate dung beetle assemblages are dominated by species of the genus *Aphodius*. They generally lay eggs within fresh dung pats or at the pat–soil interface. Following egg hatching, larvae pass through three larval stages and a pupal stage before adult emergence. Development times range from three to five days for hatching of eggs, four to six weeks for larvae, and one to four weeks for pupae.

Dung beetles (adults and larvae) are an important component of the decomposer community in dung pats. During the drier summer months when earthworms are inactive (although they have been busier this summer!), dung beetles are the dominant agent of dung decomposition. Their feeding and movement activities within dung pats contribute to dung degradation. They form tunnels as they feed and move through dung, aerating dung pats and stimulating the release of ammonia, and inoculating dung with microorganisms. While earthworms are considered to be the primary dung decomposer faunal group, beetle activity appears to create favourable conditions within dung pats (such as loosened dung structure

and reduced ammonia concentrations), which facilitate eventual earthworm colonisation and dung removal. In addition, the activity of dung beetles in the soil underneath the dung pat contributes to soil fertility and soil structure. Dung beetle adults and larvae are also very important prey items for a number of vertebrate species, including those of particular conservation concern (e.g., the chough *Pyrrhocorax pyrrhocorax* and lesser horseshoe bat *Rhinolophus hipposideros*). Grazing by livestock results in the deposition of large quantities of dung on pastures, with an average cow producing 10 to 12 dung pats per day. Dung pats in north temperate regions may persist for several weeks, with the rate of decomposition being determined by a combination of abiotic (weather effects) and biotic (microbial and invertebrate) factors. Decomposition of dung is ultimately important to prevent pasture fouling by ageing dung and pasture rejection by animals, to reduce breeding sites for pest flies, and to maintain nutrient cycling within grazed pastures. Dung beetle activity and diversity are threatened by a range of land use developments and animal husbandry practices. There are anecdotal accounts of widespread declines in dung beetle diversity across Europe, and it is unclear what impact this may have on dung decomposition in pastures.

Anti-parasitic compounds

Anti-parasitic compounds, in particular avermectins, may have unintended side effects on dung beetle activity and diversity. Avermectins (e.g., abamectin, doramectin, eprinomectin and ivermectin) have been used to effectively control parasite loads in livestock for the last two decades and have since become an integral part of livestock husbandry globally. They are mainly administered to livestock by injection, topical/pour-on preparations, or intra-ruminal sustained-release boluses, and often at recommended repeated intervals such as three, eight and 13 weeks following spring turnout of livestock. Avermectins are excreted in a predominantly unmetabolised form in dung, and their concentration and persistence in dung is influenced mainly by the dose quantity and mode of drug administration. For example, peak ivermectin concentrations in dung are detected three to five days post injection, but ivermectin can continue to be excreted in dung up to 35 days post injection.

Environmental concerns

A variety of anti-parasitic drugs have successfully contributed to animal production and welfare. Amid concerns about the knock-on impacts of avermectins, which may result in the death of beneficial insects, new toxicity



Trypocoris pyrenaeus.

Reproduced with permission from Dr Rosa Menendez.

testing protocols are being developed to assess impacts on biodiversity. Ultimately, the aim is to develop effective anti-parasitic drugs that minimise or eliminate the unintended environmental effects. Reductions in the numbers of beneficial dung fauna could have negative effects on dung degradation, nutrient cycling, and availability of food for the many wildlife groups that feed on dung insects. In a two-year study at Johnstown Castle Environment Research Centre, we investigated how ivermectin impacts on the entire life cycle of north temperate species for the first time by administering ivermectin to cattle and allowing beetles to develop in dung from treated and untreated cattle. Ivermectin significantly reduced larval survival (and thus emergence of new beetles; **Figure 1**). In laboratory experiments, it took longer for larvae to develop in dung with ivermectin than in dung without it. This is a significant finding because larval development needs to be completed before the dung pat dries out or decomposes. We also showed that ivermectin persisted in pats for a prolonged period, i.e., at least five weeks post treatment of cattle. As demonstrated in this and other studies, low emergence from pats results in reduced dung beetle populations in dung where avermectins are present, and the persistence of avermectins in pats indicates that beetles may be exposed for prolonged periods. The two most common Irish dung beetle species showed quite different responses to ivermectin. For instance, larvae of *Aphodius rufipes* were able to survive higher concentrations of ivermectin than those of *Aphodius ater* when ivermectin was topically applied to larvae. These differences indicate that life stages of different species can vary in their responses to ivermectin. It is difficult to estimate the extent to which the unintended effects of avermectins impact dung beetle (and other decomposer) populations at larger geographical scales. However, risk assessments tend to include factors such as the spatial and temporal distributions and abundance of dung faunal populations, treatment timing, and the number of treated livestock. Climate, season, and species also determine the environmental effects of avermectins, as does the dose, application frequency and excretion pattern of the administered compound. Interestingly, relatively little is known about the usage patterns of veterinary medicines in the USA and the EU, as there is no legal requirement to record such information. Knowledge about the amount, extent and type of veterinary medicines in use is essential in order to ultimately predict the potential threat

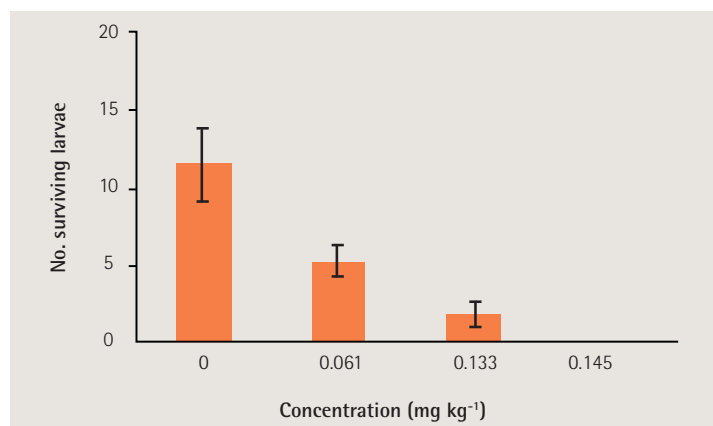


FIGURE 1: Mean number (± 1 s.e.) of surviving larvae of *Aphodius rufipes* ($n = 10$) in dung with different concentrations of ivermectin (mg/kg, wet weight). Overall, higher concentrations of ivermectin reduced larval survival.

that medicines pose for non-target dung fauna at local (e.g., farm) level and larger, regional, scales.

Conclusions

Policy-makers are increasingly concerned about the effects of antibiotics, anti-parasitic chemicals and other medicinal treatments on farmland biodiversity. At present, restrictions on the use of avermectin apply to organic farming and some areas of high nature conservation value. In designated conservation areas, where species with vulnerable populations are dependent on dung beetles as prey, restrictions on avermectin usage are of particular importance. This study helps to address the need for evidence-based conservation management, and may also guide the development of more targeted agri-environment measures for locations where this is most effective and appropriate.

In response to these and related concerns, formal ecotoxicology programmes are being initiated at EU level to systematically screen for the unintended effects of anti-parasitic compounds on soil organisms, including dung beetles. Due to differences in the relative sensitivity of different life history stages (egg, larva, adult), and across different species, our work indicates that such screening programmes need to include a variety of life history stages for a number of species. Overall, this should help to achieve the balance between the use of anti-parasitic compounds for the protection of animal health and welfare, and minimisation of the unintended knock-on effects on nutrient cycling from dung pats, and impacts on farmland wildlife.

Norma O'Hea is a Walsh Fellow and **Dr John Finn** is a Senior Research Officer based at Johnstown Castle Environment Research Centre, Wexford. The university supervisor was **Professor Paul Giller** of UCC (not pictured).

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What lies beneath: digging deeper into the science of soils

The soil ecosystem that enables good crop growth is surprisingly poorly understood. Researchers at Johnstown Castle Environment Research Centre are delving into soil biomass to discover the hidden species that recycle our nutrients.

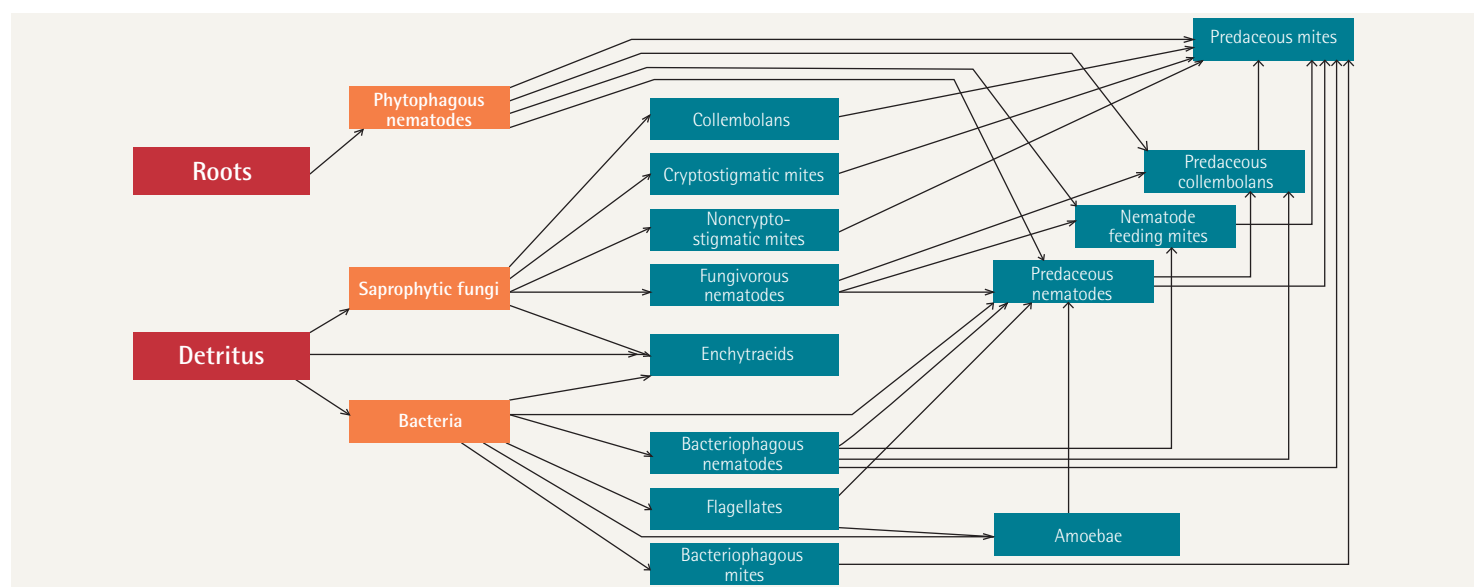


FIGURE 1: Soil food web. Adapted from De Ruiter et al. (1993).

Soil has been called the 'poor man's rainforest' on account of the huge biodiversity (number of different species) occurring beneath our feet (Giller, 1996). A handful of soil will contain 10,000 bacterial species, in addition to the fungi, protozoa, nematodes, mites, springtails, worms and insect larvae that also live there. An interesting comparison is that 1m³ of soil hosts as many species as 1km³ of ocean (one billion tonnes of water). Furthermore, not only are there unimaginably large numbers of different creatures, they are organised in complex food webs.

Soil biomass and nutrient cycling

These soil organisms, or the 'soil biomass', have been described as the eye of the needle, through which all soil matter must pass. This is because any material entering the soil – dead plant material (crop residues, dead roots and root exudates), dead organisms, animal manure, pesticides, pollutants, fertilisers – is decomposed and recycled by the activities of the soil biomass. This decomposition takes place in biogeochemical cycles, some of which have been well documented, e.g., the nitrogen (N) cycle.

A significant proportion of the nutrients taken up by plants is derived directly from this mineralisation. Recycled N feeds the soil biomass, which subsequently recycles that N for plant growth. The supply of N released by the biomass

through mineralisation varies widely between soil type, nutrient management history and (soil) ecosystems. Therefore, an understanding of the soil biomass – what it is, how it works, and how we can manage it – is central to an understanding of nutrient cycles in managed systems.

Traditionally, the biggest challenge in understanding the dynamics of the soil biomass has been identifying which organisms are present. Most of the species are of microscopic size, and some of the smallest organisms (bacteria, fungi, protozoa), which cannot be extracted directly from the soil, cannot even be cultured in the laboratory. Only about 10% of bacteria found in the soil, for example, can be grown on laboratory media. And even for those organisms that can be extracted from soil (the larger fauna such as nematodes, mites and collembola), identification is a highly specialised job.

Researchers at Johnstown Castle Environment Research Centre are developing and applying a novel method to identify nematode species from soil based on analysis of nematode DNA.

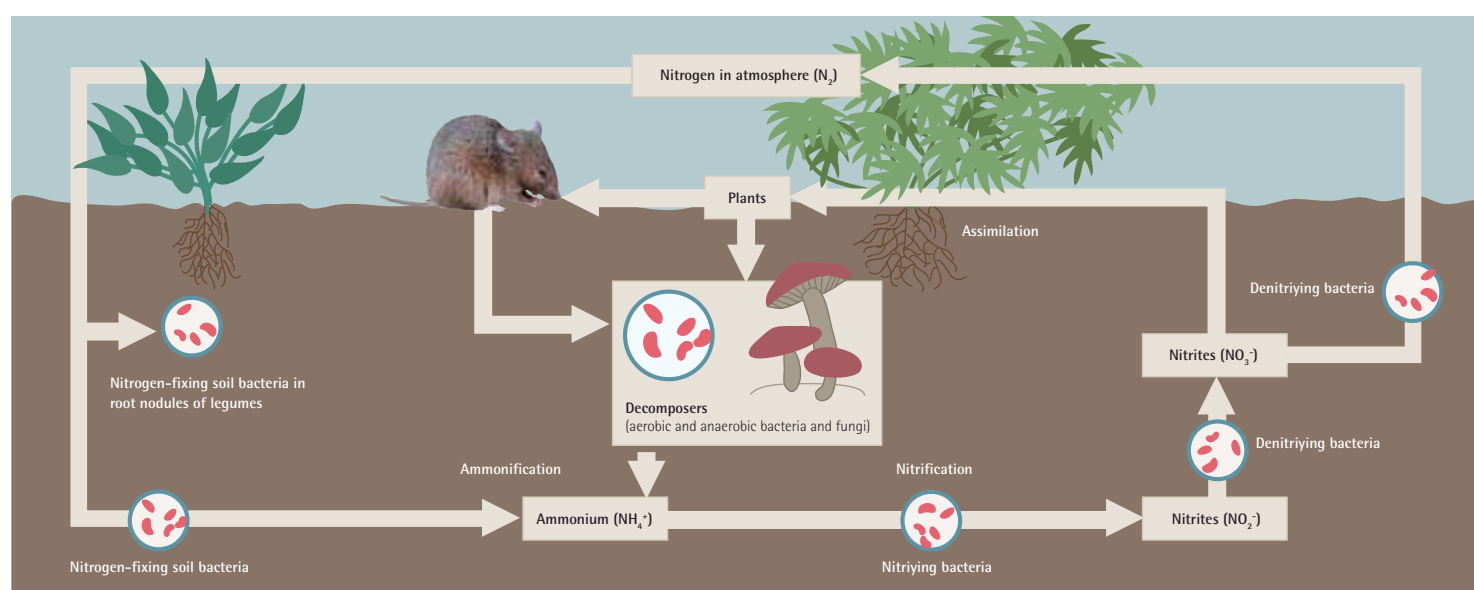


FIGURE 2: The nitrogen cycle.

Molecular techniques

Recent advances in the analysis of nucleic acids, particularly DNA, mean that it is becoming possible to identify these organisms, even though they cannot be grown in the laboratory or extracted from soil. At Johnstown Castle Environment Research Centre, we are now developing and applying a novel method to identify nematode species from soil, based on analysis of nematode DNA (Griffiths *et al.*, 2006). This has the potential to allow a far greater throughput of samples: expert identification using microscopes allows nematodes from 40 samples per week to be identified, whereas more than 200 samples would easily be obtained using the new molecular method. We have selected nematodes as the focus of our study because these organisms fill all trophic (nutritional) positions in the soil food web, e.g., there are nematodes that feed on bacteria, fungi, plants and other animals. So by mapping the nematode community, we can open the black box of soil biology: whether it is stable, enriched, or disturbed, whether the soil has a fast or a slow decomposition pathway, and how this affects nutrient cycling.

This information is critical as we become more aware of soil quality and the importance of maintaining a healthy soil. Our new ability to accelerate sample processing, using the now widely available molecular skills rather than the traditional taxonomic skills, allows us to utilise the nematode community structure as an indicator of soil quality. We can now begin to address complex

ecological questions that take spatial and temporal variation and effects of soil depth into consideration.

Who controls the nitrogen cycle?

Teagasc has a large and ambitious research programme aimed at reducing the losses of N to water and air (Schulte, 2006), which includes minimising nitrate leaching and nitrous oxide emissions. Our new microbiological and molecular research laboratories at Johnstown Castle, installed as part of the Vision Programme, have given us the molecular biological capabilities and facilities required to start examining the microorganisms within the soil biomass that govern the N cycle. Surprising as it may seem, there is even uncertainty over which types of organisms are involved. There are three major forms of life – archaea, bacteria and eukarya (fungi in this instance). All three forms have been shown to be key players in different ecosystems and under different conditions; therefore, the processes determining nitrate and nitrous oxide losses may differ between countries, and indeed between farms. We will be using the new facilities at Johnstown Castle to achieve a better understanding of the microbes involved in the N cycle on Irish farms.

Molecular techniques allow us to dig deeper into the soil ecosystem, and unlock the 'black box' of nutrient cycling and mineralisation. This will give us a better

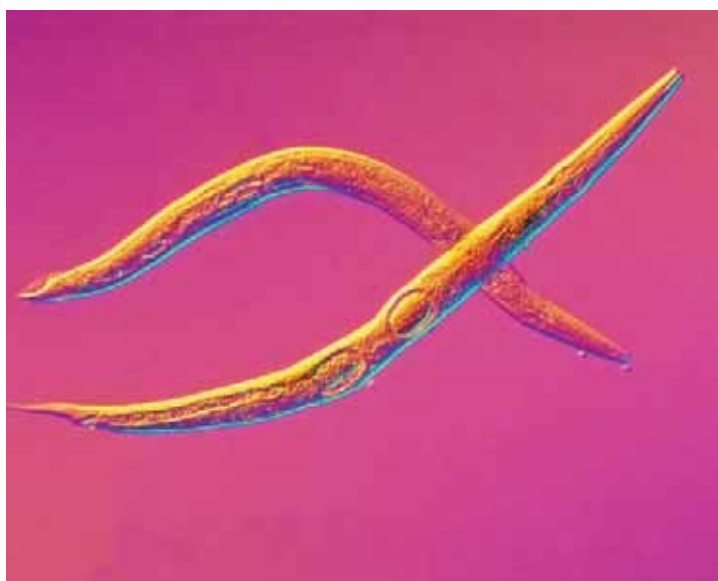


FIGURE 3: Soil nematodes, 200µm (0.2mm) long.

understanding of N pathways and transformations, and help us to develop strategies to make maximum use of increasingly limited resources and minimise losses to the environment.

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Farm fatalities in the



Irish farmers could be more at risk of having a fatal farm incident, with the Irish farming population getting older and fewer young entrants to the profession. DAVID MEREDITH in the Rural Economy Research Centre, and JOHN McNAMARA, Teagasc Safety Officer, have been monitoring trends in this area.

Introduction

In the period from 1993 to 2007 an average of 18 fatal farm incidents occurred each year, representing approximately 25% of all fatal workplace incidents. Though the number of accidents has declined in recent years, the agriculture sector remains, when one considers the number of persons employed, the second most dangerous industry in Ireland, after commercial fishing. In response to the high level of fatal incidents in the agricultural sector a statutory body, the Farm Safety Partnership, was established comprising industry stakeholders, the Health and Safety Authority (HSA) and Teagasc, to advise on measures to reduce accidents and fatalities on farms. Teagasc, as part of its contribution to the partnership, is undertaking a detailed assessment of fatality trends. This paper provides a summary of the results generated to date and outlines some of the implications of these findings.

Data

The HSA collects information and data on all fatal workplace incidents through its inspectorate. Details pertaining to the age and gender of the victim are recorded, in addition to the time, place and cause of the incident. Teagasc, working with the

Republic of Ireland

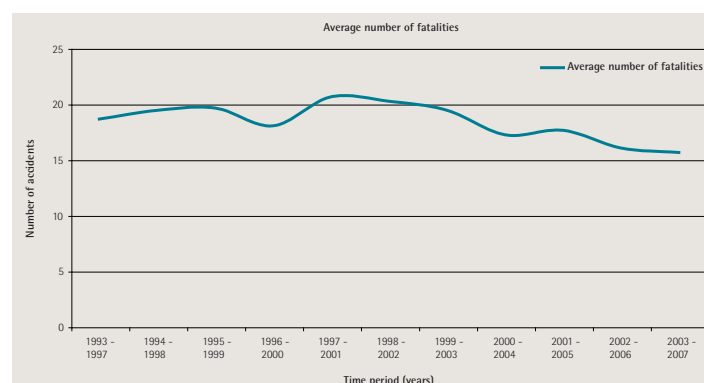


FIGURE 1: Average number of fatalities 1993–2007 on a five-year moving average.

HSA, has developed a dataset of fatal farm incidents covering the 1993 to 2007 period. This resource facilitates analysis of fatality trends and is the primary source of data used in this paper. Additional data regarding the number and age of persons working on farms is taken from the Census. These data enable the fatality rate, the number of deaths per thousand workers, to be calculated.

Fatal farm incident trends

The number of fatal accidents varies widely from year to year, e.g., there were 17 incidents in 2006 and 11 in 2007, a 65% decline; however, by July of 2008 the number of fatalities had surpassed the 2007 total. Given this variability, assessment of the average number of incidents over a number of years provides a clearer indication of dominant trends. Taking a five-year moving average, one finds that, since the late 1990s, the overall number of fatalities has declined by 24% (Figure 1). This decline is largely driven by the reduction in the number of persons working in the agricultural sector, which fell from 133,969 to 89,277, a fall of 33%, between 1996 and 2006 (CSO, 2006).

While this substantial decline in fatalities is encouraging, an assessment of the fatality rate gives cause for concern. Using the number of persons working in the agriculture sector published by the Central Statistics Office (CSO), it is estimated that the farm fatality rate increased from 1.39 to 2.01 per 10,000 persons employed between 1996 and 2002. This trend is primarily driven by the increase in the number of older farmers who, analysis demonstrates, are more likely to experience a fatal accident. Results indicate that the number of persons under the age of 55 experiencing fatal incidents declined by 58%, while those over 55 saw a 63% increase between 1993 and 2007. Unlike other economic sectors, farming is characterised by an older labour force; 23% of the agricultural workforce is over 65 years of age, in comparison to 5% of all other economic sectors. This is significant given that Ireland's farm workforce is set to age relatively rapidly in the coming

years because of low levels of recruitment into the industry and the absence of successors on many farms. The implication of this analysis is that we may see an increase in the number of fatal incidents in the coming years driven by ageing of the workforce unless appropriate interventions are instituted.

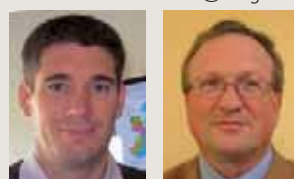
There is also a geographic dimension to these trends, with more fatalities occurring in the border and Midland Regions. Once again this is related to age, with older farmers, particularly those over 65, concentrated in these areas.

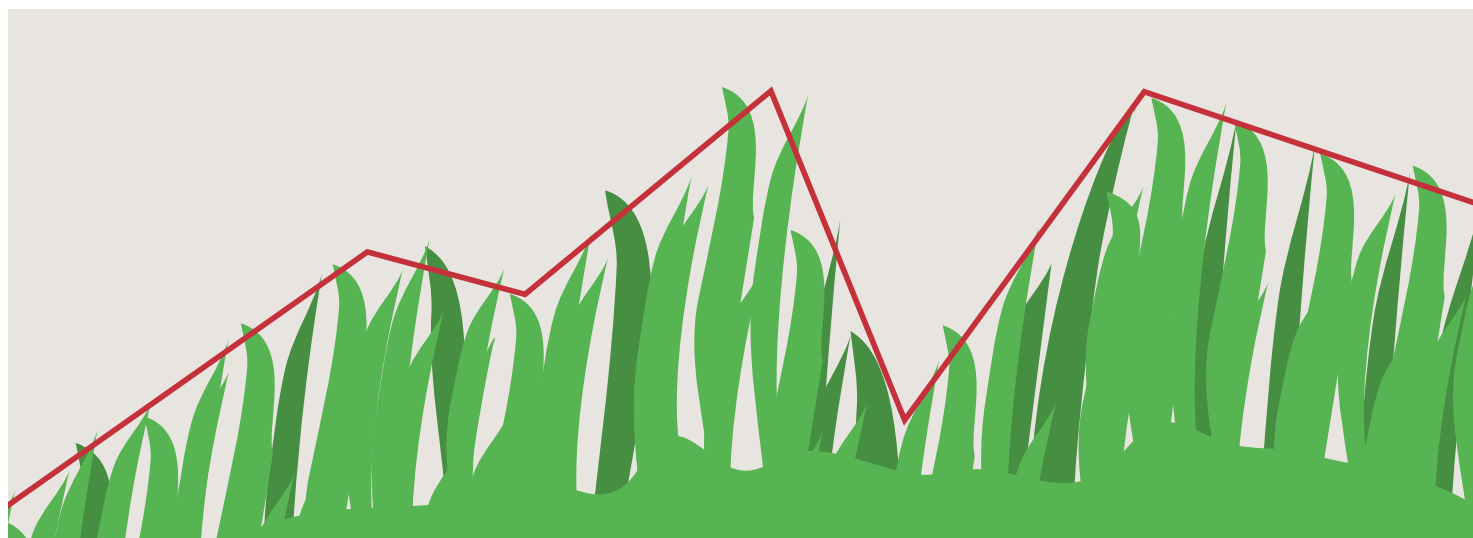
Conclusions

This research demonstrated the role of age in understanding the number of fatal farm incidents. Of particular concern is the high fatality rate associated with older farmers given the current demographic structure of the agricultural workforce. Current low levels of recruitment to the industry, particularly to the beef and sheep sectors, will result in relatively rapid ageing of the farm population, which, if contemporary trends remain unchanged, may result in increased fatalities.

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Understanding productivity growth in Irish agriculture

Over any time period other than the very short term, the main source of change in competitiveness comes from differences in the rate of productivity growth. Researchers at Teagasc's Rural Economy Research Centre and colleagues at Trinity College Dublin examine the productivity performance of Irish agriculture.

The Irish agricultural sector has long been supported by protectionist policy interventions that have distorted incentives for farmers to produce at the optimum from a market perspective. However, recent reforms of the Common Agricultural Policy, and continuous moves towards further trade liberalisation, have meant that the competitiveness of agricultural markets has been at the forefront of debate in recent times. If we want to understand changes in relative competitiveness over time we need to look at the relative movements in the three factors that contribute to competitive positioning: relative productivity growth rates, relative changes in costs, and relative changes in price of output. Over any time period other than the very short term, the main source of change in competitiveness comes from differences in the rate of productivity growth. This motivation provided the rationale for researchers in the Rural Economy Research Centre (RERC), Teagasc, and the Department of Economics in Trinity College Dublin (TCD) to examine the productivity performance of Irish agriculture.

This research employed an economic tool called stochastic frontier analysis (SFA) for the construction of total factor productivity (TFP) indices for each of the main farming types in Ireland, using National Farm Survey (NFS) data from 1996 to 2006. An index of TFP measures productivity growth, taking into account the relationship between the change in output and the change in the use of all inputs. This measure of productivity growth differs from traditional 'partial' productivity indicators common in the literature, which compare

output to a single input such as land, labour or animal numbers (for example, milk yields per cow or crop yields per hectare).

An index of TFP breaks annual TFP change down into technical change, technical efficiency change and scale efficiency change. While the analysis is primarily concerned with changes in TFP and its components over the time period 1996 to 2006, a complementary issue is also explored that examines the factors that influence technical efficiency levels in Ireland.

Productivity growth in Irish agriculture

TFP growth over the period 1996 to 2006, as shown on **Figure 1**, is highest in the cattle rearing sector followed by the dairy, cattle finishing, sheep and cereals sectors. Average annual TFP growth rates are 2%, 1.4%, 0.9%, 0.4% and -0.2%, respectively. The cattle and dairy sectors show broadly similar trends for the period. In general, 1998 and 2002 appear to show TFP declines in all sectors, while improvements are evident in 2000 and 2004.

It is interesting to compare the TFP results from the current study to those obtained by Newman and Matthews (2004), who explored TFP growth for an earlier period, 1984 through 2000. Their results showed that TFP growth was highest in the sheep sector, followed by the dairy, cereals, cattle finishing and cattle rearing sectors (considerable 22% decline in this latter sector), and average annual growth rates were 1.8%, 1.1%, 0.9%, 0.2% and -1.4% for these sectors, respectively, over the period 1984 to 2000. Although not strictly comparable with the current study, a

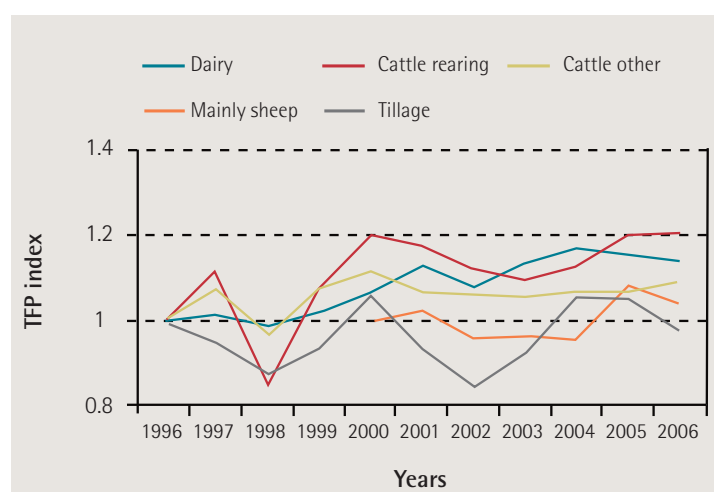


FIGURE 1: Weighted cumulative total factor productivity growth by sector, 1996 to 2006.

number of TFP changes are evident. The cattle rearing sector, which displayed considerable TFP declines up until 2000 in the earlier study, has clearly improved in the current study, which examines TFP growth up to 2006. Based on this result, it is likely that the high growth rates for this sector in the current study are due to a poor starting point in the mid 1990s. The dairy sector has continued to improve and average annual growth rates have increased from 1.1% (previous study, 1984 to 2000) to 1.4% (current study, 1996 to 2006). Results from Newman and Matthews (2004) for the sheep sector showed remarkable improvements up until 1993 (43%) before declining significantly up until 2000 (14%). It is evident from the current study that this later decline has slowed and reversed (TFP has improved in the 2000 to 2006 period), which is likely associated with a fall off in sheep farm numbers and the survival of the more productive farms. The cereals sector displays improvement in the 1984 to 2000 period but has shown small TFP declines in the present study. Finally, productivity in the cattle finishing sector has improved – average annual TFP growth has increased from 0.2% in the previous study to 0.9% in the current study. Trends in the sources of TFP growth, namely scale and technical efficiency, were also examined for the time period. Notable increasing returns to scale were found to be prevalent in the dairy and cereals sectors. Increases in average size would therefore lead to improvements in scale efficiency in these sectors. However, the only notable improvements in scale efficiency were evident in the dairy sector. This is expected, given that the average size of operations is increasing (the average number of cows increased from 45 in 1996 to 57 in 2006). Technical efficiency improvements are only evident in the sheep sector, while declines in mean efficiency are observed in the cereals sector. The remaining sectors show little movement.

What are the factors that influence technical efficiency?

The study also explored the determinants of efficiency in each of the NFS farming systems. It was found that efficiency levels are, in general, positively correlated with contact with advisory services (although only significantly in the dairy sector), soil quality, the overall size of the farm, the level of intensification (livestock systems) and the level of specialisation. The use of artificial insemination was also explored in the dairy and cattle rearing sectors but was only significant in the dairy sector.

The relationship between off-farm employment and technical efficiency levels was not significant in any of the sectors, which implies that farms where the farmer

has an off-farm job are no less efficient than farms without. This result highlights the need for farmers to critically analyse their on-farm time management to explore the viability of pursuing part-time employment outside of the farm. The importance of the scale of operations is of particular interest. The analysis showed that increasing returns to scale were especially evident in the dairy and cereal sectors. The results highlight that larger dairy and cereal farms are more efficient. This implies that increasing scale would likely lead to increases in productivity through two separate routes: higher technical efficiency levels and higher scale efficiency levels.

The degree of specialisation will also be an important issue for the competitive future of Irish farming. Higher levels of specialisation lead to higher efficiency levels in the dairy, cereals and cattle finishing sectors, but to lower efficiency levels in the cattle rearing and sheep sectors (not significant in the cattle sectors). This may be due to the poor financial position of the latter sectors and the need to expand into other sectors where possible.

Conclusions

The findings of this research have shown that productivity growth was highest in the cattle rearing sector followed by the dairy, cattle finishing, sheep and cereals sectors, during the period 1996 to 2006. Increases in average size would lead to improvements in scale efficiency in the dairy and cereals sectors. However, the only notable improvements in scale efficiency were evident in the dairy sector.

The research has also shown that efficiency levels are, in general, positively correlated with extension (advisory) use (although only significantly in the dairy sector), soil quality, the overall size of the farm, the level of intensification (livestock systems) and the level of specialisation. The use of artificial insemination was also positively correlated with efficiency in the dairy sector.

Given the importance of economies of scale found in the research, this finding presents a serious challenge for policy makers and for those involved in planning the future of Irish agriculture, which at present is characterised by relatively small scale operations (in comparison to operations internationally).

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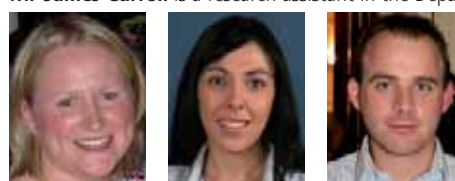
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WTO reform: what could it mean for agriculture in Ireland?

TREVOR DONNELLAN and KEVIN HANRAHAN, Teagasc Rural Economy Research Centre, outline some of the main issues of concern in the negotiations for a WTO agreement, and their potential impact on EU and Irish agriculture.



While the World Trade Organisation (WTO) negotiations ran into difficulty at the WTO Ministerial meeting in July 2008, it would be a mistake to think that agricultural trade reform, whether multilateral or bilateral, is off the agenda. Over the course of 2008 we have analysed the impact of various scenarios based on possible outcomes of the current WTO negotiations. In this article we set out the background to the key issues, detail what might be agreed and examine the potential impact of such an agreement.

Background

By the time the WTO negotiations ground to a halt in July 2008, significant progress towards a deal had been made. Of the 20 or so key areas of discussion, agreement in principle had been reached on all but two. At the time of writing, another push is being made to achieve consensus before the US Presidential elections take place. If that is unsuccessful, then for a range of political reasons, it is likely to be at least another 18 months before circumstances will be right for a push towards the conclusion of a final agreement.

The fact that the Doha Round has lasted seven years is arguably as much to do with the complexities and breadth of the trade reforms under negotiation, as it is to do with the political distance between the main negotiating blocks. The issues that led to the collapse of the July 2008 Ministerial meeting were of both a technical and political nature. In this article we do not attempt to analyse the political issues that prevented WTO members reaching agreement on modalities in agriculture and non-agricultural market access (NAMA). Rather we focus on several of the more complex trade policy issues, which are of relevance to agriculture in the EU and Ireland. These issues include sensitive product status and what are called 'tariff rate quotas' (TRQ), the impact of high quality beef imports, the management of export subsidies, and the export capacity of third countries.

What might be agreed under a WTO deal?

The issues under negotiation in the WTO are, in many cases, highly complex and the briefest of summaries is provided below detailing the three main strands of the negotiations. Two of the strands, those relating to export subsidies and trade distorting domestic support, are now largely irrelevant from an EU perspective. The EU is already winding up its export refund programmes, so new WTO constraints on export subsidisation would be largely irrelevant, while WTO disciplines on trade distorting domestic support were addressed through the introduction of decoupled direct payments in the 2003 Common Agricultural Policy (CAP) reforms.

The situation with respect to the third strand of the negotiations, market access, is very different. The market access issue relates to reductions in import tariffs, which protect higher priced markets from competition with products sold at world prices. Market access has been the main sticking point over the course of this and previous rounds of multilateral trade negotiations.

Associated with the negotiations on tariff levels are negotiations on a myriad of related issues, including sensitive products status and TRQ expansion.

Tariffs

Thus far in the negotiations, tariffs have been categorised into four tiers according to their value with respect to world prices. For bound tariffs in excess of 75% *ad valorem* equivalent (AVE), it now appears that a 70% reduction is most likely. The EU tariffs that are of interest to Irish agriculture generally fall into this highest of the four tariff tiers.

It has been proposed that WTO members can seek sensitive product status for a limited range of commodities (4–6% of tariff lines), where the absence of market protection would have the most serious consequences for domestic production.

Such sensitive product status would allow a WTO member to apply a lower level of tariff reduction than would otherwise apply. A one-third or two-thirds deviation from the non-sensitive rate of tariff cut would be allowed. If a two-thirds deviation were chosen, then in the case of the top tier tariffs, this would mean that the required reduction in the over-quota bound tariff rate would be 23.3%, i.e., a two-thirds deviation from 70%.

As a *quid pro quo* for the lower tariff reduction associated with sensitive product designation, a WTO member would agree to an expansion in its existing TRQ, the volume of imports it accepts at low or no rate of tariff.

The TRQ created in return for sensitive product designation for a limited number of product categories, such as beef or cheese, could be divided or sub-allocated to effectively create two TRQs within a product category. The advantage of such sub-allocation, from the perspective of importing countries, is that it creates an opportunity to limit the market impact of TRQ expansions. The European Union Agriculture Commissioner (Mariann Fischer Boel) has stated that such a sub-allocation would be sought for beef in the event of a WTO agreement. This would split the additional EU TRQ for beef into a TRQ for fresh and chilled beef and a separate TRQ for all other beef. The fresh and chilled beef TRQ would account for 55% of the total additional beef TRQ, with the remaining 45% allocated to the other beef category.

The issue of TRQ expansion does not arise in the case of products that are not designated as sensitive and the full tariff reduction of 70% would be applied.

Potential impact of a WTO deal

Before detailing the possible impact of WTO reform, it should be understood that the recent improvement in prices in global commodity markets has the potential to substantially change the impact that a WTO agreement would have on EU and Irish agriculture. Historically, there has been deep concern that WTO reform would pull EU prices down to world levels, which typically have been well below the price levels prevailing in the EU. However, strong worldwide economic and population growth has boosted demand for agricultural commodities, while the rate of growth in supplies has slowed relative to recent decades. Recent EU policy reforms have also tended to push EU prices lower, and together these factors have brought world and EU price levels much closer together for many agricultural commodities. The immediate implication of this is that the impact of WTO reform on EU agriculture is likely to be more limited.

Sensitive products – beef and dairy contrasts

One of the main strategic decisions the EU faces in the WTO negotiations is which products it should declare as sensitive. Beef and poultry are considered to be two of the more likely candidates. While this decision will be political in part, economics can also shed light on this question. Put simply, sensitive product status, which would imply lower tariff cuts in exchange for expansion in TRQ, is less attractive to the EU for those commodities where the existing import level is equal to or less than the existing TRQ. In such cases the high over-quota tariffs (even with a 70% reduction) are effective in preventing or limiting over-quota imports (imports beyond the TRQ level), and any increase in TRQ is likely to bring about an increase in imports. Conversely, if imports already exceed the TRQ amount (implying that existing over-quota tariffs are already somewhat ineffective), an expansion in the TRQ does not in itself increase imports. Dairy and beef production, the two main enterprises in Ireland, fall into one or other of these two categories.

Teagasc research shows that, at the EU level, dairy imports from third countries would increase if TRQ were expanded, while the full reductions in tariffs (even where the reduction is 70%) are unlikely to greatly increase imports of dairy commodities. Beef, however, is another story. EU beef tariffs are already ineffective in preventing imports of higher value beef cuts. EU beef imports are likely to increase whether or not WTO reform occurs, and could reach over 9% of EU beef consumption by 2017. If a WTO agreement is reached, then the increase in EU beef imports will be even greater, and sensitive product status is likely to be chosen to limit the extent of the increase in imports that would occur. Without sensitive product status, the decline in EU beef tariffs would make a greater range of tariff-paid imported third country beef cuts price competitive on the EU market. EU third country beef imports would increase from 9% to 18% of EU consumption by 2017. Sensitive product status has the capacity to constrain EU imports to 12% of EU consumption by 2017.

The prospect of a WTO agreement highlights the contrasting fortunes of the dairy and beef sectors. The increase in third country dairy imports into the EU due to WTO reform is likely to be minimal. Butter prices are likely to fall considerably in the absence of export subsidies but, overall, dairy product prices will not be influenced greatly, and the impact of a WTO agreement could be confined to a decline of 2-4% in farm milk prices. This would have a minimal impact on the volume of milk produced in the EU. By contrast, research conducted at Teagasc's Rural Economy Research Centre shows that the extent of the increase in beef imports that could occur under a WTO agreement would have a significant negative impact on beef prices in the EU, particularly if sensitive product status is forgone. However, even with beef declared as a sensitive product, the decline in beef prices will only be restricted to a fall of 10% compared to the price level if no agreement is reached.

The ongoing difficulties faced by the Irish beef sector are highlighted by the fact that a significant contraction in suckler beef production is likely to occur even if a WTO agreement does not occur. The introduction of the Suckler Cow Welfare Scheme will inject funds into the sector, but the scheme is scheduled to end in 2013. After that, Irish beef farmers will once again have to rely solely on market returns to make beef production profitable. Even if farmers choose to mentally recouple their SFP to beef production, the fixed nature of the payment means that its value will be eroded over time by inflation so it will not have the capacity to boost farm incomes in real terms.

Ultimately, some beef farmers will exit production and some will restructure to cope with the more difficult market environment of the future, but it is difficult to escape the conclusion that at least some of the vast increase in Irish suckler beef production that occurred on foot of the introduction of the MacSharry reforms in 1990, will be lost over the next decade, irrespective of whether or not a WTO agreement is reached.

Full details of the WTO analysis are available on the FAPRI-Ireland website at www.tnet.teagasc.ie/fapri.



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T Technology opportunities

Technology opportunities at Teagasc



Rapid assessment of bacterial load in perishable foods, a PCR-based approach
Licensing opportunity Ref: CO 002

Abstract:

A rapid means of evaluating microbiological quality of perishable food products has been developed, based on a specific nucleic acid-based assay, which measures both gram-positive and gram-negative bacteria.

This method, developed at Ashtown Food Research Centre by Dr Geraldine Duffy's research group, based on a specific PCR detection, has been validated against the gold standard total visible count method for meat and offers time and precision advantages to clients for microbiological assessment and shelf-life prediction of perishable food products.

Background

The microbial quality and safety of a food is dependent on the microbial load, diversity and composition of the microflora. The cultural total viable count method (TVC) is the gold standard used to evaluate microbiological quality and predict shelf-life of a food product. Although this method is slow, and can be biased, all alternative methods must generally be correlated or validated against this method. Where a rapid result is required, culture-dependent techniques may be unsuitable, as they can take several days to provide a result.

This development is designed to overcome these limitations by allowing more rapid and specific detection of both gram-positive and gram-negative bacteria of food products within 24 hours, while also allowing more accurate prediction of shelf life. This technique has been validated for meat products specifically, and has significant potential for development/validation for other perishable meat, fish or poultry products.

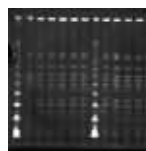
Opportunity/commercial potential

The commercial potential of this technology is significant in the perishable food industry, with the potential to offer more rapid and specific means of assessing microbial load and shelf-life prediction.

In terms of licensing, this technology would be of interest specifically to independent laboratories testing meat for food companies, or potentially food companies with their own laboratories, wishing to provide speed and precision advantages in testing. The laboratories would need to be equipped with PCR facilities and possess relevant expertise.

Intellectual property status

Teagasc filed a European patent application in 2008 covering a nucleic acid-based method to assess the bacterial load of a perishable food sample.



Method of detecting a source of blown pack meat spoilage, a PCR-based approach
Licensing opportunity Ref: CO 003

Abstract:

Blown pack spoilage of vacuum packaged meat by psychrophilic Clostridial species is a serious problem for the meat industry, costing many millions of Euro per annum. A means of detecting a previously unknown source of blown pack spoilage in meat products has been developed in conjunction with the discovery of a new strain of Clostridia proven to cause such spoilage of meat.

This method is based on a specific real-time PCR detection and the development of specific primers based on the isolated strain of Clostridia. Prior to the discovery of this new Clostridial strain, it was not possible to detect all sources of blown pack spoilage.

Background

Spoilage of vacuum-packaged meat has become a major problem and cost for the beef industry, due to the associated putrid smell and unusual sheen of affected meat. Although this is a food quality rather than safety issue, meat spoiled in this way has no commercial value. While vacuum packing is an effective means of preserving meat and extending shelf life, blown pack spoilage can occur when the spores of psychotropic or psychophilic Clostridial species contaminate the meat prior to packaging, costing the Irish beef industry many millions of Euro. While there are methods available to detect the presence of two strains of Clostridia known to cause this spoilage, negative tests did not always predict non-spoilage of product. A third strain of Clostridia, capable of causing blown pack spoilage in meat, has recently been discovered by Dr Declan Bolton and his team at Ashtown Food Research Centre. This has facilitated the development of a single PCR-based method to detect all three Clostridial sources of blown pack spoilage.

Opportunity/commercial potential

The commercial potential is significant due to the potential cost saving implications for the Irish beef industry.

Access to this technology would give an organisation the potential to offer a comprehensive means of detecting all sources of blown pack spoilage, in conjunction with methods already developed for the two other known Clostridia strains causing this spoilage.

Intellectual property status

Teagasc filed a European patent application in 2008 covering the isolated strain of Clostridia and a nucleic acid-based method of detection of this previously unknown source of blown pack spoilage.

For further information on development and licensing opportunities contact: Miriam Walsh, PhD, Intellectual Property Officer, Teagasc.
E-mail: miriam.walsh@teagasc.ie; Tel: 059 918 3477; Mob: 087 911 3960.

T Events



This year marks the 50th anniversary of AFT (now Teagasc). AFT 50 events have taken place at Teagasc research centres, and will take place at the events marked below. A DVD marking the anniversary was launched at the Foresight conference and a commemorative book was also launched (see news pages).

November

Kildalton, Gurteen College, Botanic Gardens, Mountbellew, Ballyhaise, Pallaskenry and Clonakilty Colleges

Teagasc colleges open days

See web for details of dates for open days at each college.
www.teagasc.ie/events

November 9–16

Teagasc research centres nationwide

Science Week

This year's theme is 'Science shaping our world'. Visits from local secondary schools will take place at the research centres in Ashtown, Athenry, Grange and Moorepark. Third-level students from Carlow IT will visit the research centre in Oak Park. Kildalton is holding a 'Feeding for Profit' conference and Johnstown Castle Environment Research Centre is holding an international conference (see below).

The Walsh Fellowships seminar will take place on November 12 at the RDS (siobhan.culleton@teagasc.ie). Dr Don Thornhill, Chairman, National Competitiveness Council, Forfás, is the guest speaker.

The seminar will be followed by a lecture on 'The twin global insecurities: food and energy', given by Teagasc Director Professor Gerry Boyle as part of the RDS Speaker Series and under the auspices of the RDS Agriculture and Rural Affairs Committee at 6.00pm (contact: lectures@rds.ie to book a place).

www.scienceweek.ie; www.rds.ie

November 12–14

Teagasc, Johnstown Castle, Wexford

Sustainable Grassland Production in Europe and the Water Framework Directive

This international conference will include policy makers, researchers, farmer representatives, local and regional authority staff, and River Basin District experts. The objectives are:

- to provide background on the EU Water Framework Directive (WFD) and implications for sustainable grassland production;
- to present the water quality standards to be achieved under the WFD;
- to identify the challenges facing grassland agriculture from the WFD in light of trade liberalisation and the end of the EU milk quota system; and,
- to present strategies that will help intensive grassland systems comply with the WFD.

The programme will include presentations by national and international experts in this area.

WFDconferencesubmissions@teagasc.ie

www.teagasc.ie/events

November 26–27

Rochestown Park Hotel, Cork (26), and

Hodson Bay Hotel, Athlone (27)

National Dairy Conference

The theme of this conference is: "Is dairy farming the solution?" The conference will cover three theme areas: availing of the opportunities; zero tolerance to farm costs; and, 'new' technologies to overcome price-cost squeeze. Teagasc's new chairman, Dr Noel Cawley, will chair the first session.

T: 090 662 6166

mary.mcdermott@teagasc.ie

www.teagasc.ie/events

December

December 2

Tullamore Court Hotel

Teagasc Organic Production Research Conference

The conference will cover four theme areas: farm management, environment and animal health; milk, beef and lamb production; crop rotation and nutrient replacement; and, analysis and attitudes. Minister Trevor Sargent, TD, will open the conference.

gerry.scully@teagasc.ie

December 9

Tullamore Court Hotel

Situation and Outlook on Agriculture 2008/09 Conference

Production economists from the Rural Economy Research Centre will review the situation and assess the short-term economic outlook for the dairy, beef, sheep, pig, cereal and forestry enterprises. Income from agriculture in 2008 will be presented, showing output from the main sectors and categorised inputs. Farmers' actual investment for 2008, and their planning intentions on investment and enterprise mix for 2009, will be outlined. Farmers, agricultural consultants/advisors and the agribusiness sector will be provided with up-to-date data on agricultural outputs, inputs and policy changes in planning their business. The conference will also be of interest to staff in state and semi-state bodies, suppliers of farm inputs, academics and others interested in the state of the farming economy.

T: 091 845 863

marion.moloney@teagasc.ie

2009

March

March 12–13

Tullamore Court Hotel

Agricultural Research Forum Meeting

The Agricultural Research Forum (ARF) is a resource that provides Irish agricultural researchers with a means to inform colleagues about their work. Areas covered include animal and crop science, environmental and soil science, food science, agri-economics, forestry and related topics.

The annual meeting of the ARF provides an opportunity for the presentation, discussion and publication of research results.

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www.agresearchforum.com

Leading the knowledge-based development of Ireland's Farming and Food Industry



Teagasc, the Agriculture and Food Development Authority, generates and applies new knowledge for the sustainable development of agriculture and the food processing industry to enable it to respond profitably to consumer demands and requirements and contribute to a vibrant rural economy and society.

Through the continuing development of Centres of Excellence in biotechnology, Teagasc will implement new research strategies based on scientific excellence, to underpin the long term knowledge needs of the agri-food industry.

Teagasc research science focuses on:

- Enhancing competitiveness through innovation in sustainable agricultural production and the food-processing sector
- Strengthening our capacity in molecular biology and gaining an increased understanding of living organisms with a view to increasing their application in the agri-food industry
- Providing sound scientific basis for decision-makers in protecting the integrity of the food chain, protecting the rural environment and addressing the concerns of the consumer
- Analysing and projecting the impact of policies for the agri-food sector
- Nourishing links with academic institutions through the Walsh Fellowship Postgraduate Programme

To deliver our ambitious scientific programme,
Teagasc needs to continuously attract and recruit the best and brightest people.

Details of opportunities are available on
www.teagasc/careers.ie

