

T Research

Research and innovation news at Teagasc

Producing better beef

Dairy cow welfare
Innovation on Irish farms
Breed composition of the national sheep flock

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Food security: a global challenge

Food security at its basic level means both physical and economic access to enough food for an active, healthy life. But, of course, for developed countries in particular, the concept means much more. The World Health Organisation definition includes sustainability of production and distribution, the nutritional adequacy and cultural acceptability of food, and the upholding of human dignity in its production.

Many consider that along with energy security, food security may well be the major issue of our time. Rising food prices have had a dramatic impact on food security, particularly in the developing world. To this must be added: the impact of climate change, which will exacerbate existing pressures on food production; the growing use of food and feed crops and land traditionally devoted to food crops for energy purposes; rapid growth in world population and the ability of food production to keep pace; and, demands for higher quality diet. With limited arable land available, there is a need to sustainably maximise production from land that is already under cultivation.

As a food-producing nation, Ireland has a responsibility to ensure that the issue of food security features at EU level and that the growing risks to the security of our food supply are addressed in a way that ensures that Europe's own population has access to a secure supply of safe and healthy food. It must do this without compromising on its responsibilities under the United Nations' Millennium Development Goals to reduce poverty and hunger and maintain its international leadership in food security and food aid. This calls not alone for research and knowledge policies, but for a broader range of policies and actions that place citizens' concerns about food security at the top of the agenda, and that stimulate the production of high quality, affordable food, while ensuring a fair distribution of rewards between the various actors in the food production and processing chain, and protecting the environment.



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New Assistant Director of Food Research



Dr Bryan Hanley has joined Teagasc as Assistant Director, Food Research, and will be based at Moorepark. Dr Hanley graduated from the University of St Andrews with a degree in chemistry. He subsequently gained a PhD in biological chemistry from the University of Edinburgh. He has previously worked for Glaxo, the Institute of Food Research, Norwich, the Rowett Research Institute, Aberdeen, and the Central Science Laboratory, York. After a

secondment to the European Commission, he returned to the UK as Research Director at Leatherhead Food International. During his time there he set up the Nutrition Department. He left to take up a post as Associate Director, Discovery, with Mead Johnson Nutritionals, based in the UK. His most recent post was at Martek Biosciences as Director, Regulatory and Scientific Affairs, Europe. Dr Hanley has published papers and reviews in the areas of natural product chemistry, biosynthesis, *in vitro* model systems, biomarkers, low water enzymology and molecular detection methods. He has also published in trade journals and appeared on television and radio.

Johnstown Castle AFT 50th celebration

As part of the An Foras Talúntais 50th celebrations, Johnstown Castle Environment Research Centre held an open day on May 1. The new 'Green Book' outlining recommended fertiliser applications was launched. An event to mark 50 years of research at the centre also took place. Research results on slurry and nutrient efficiency, and on ammonia emission from cattle slurry spread on grassland, were presented.



Pictured at the event are (from left): Noel Culleton, Head of Centre, Teagasc Johnstown Castle Environment Research Centre; Professor Patrick Cunningham, Chief Scientific Adviser to the Government; Tom O'Dwyer, Teagasc Chairman; and, Professor Gerry Boyle, Teagasc Director.



Attendees at Johnstown Castle Environment Research Centre's An Foras Talúntais 50th celebration event.



Farmfest 2008

Over 30,000 people enjoyed the sunshine at Farmfest 2008, Teagasc's major outdoor exhibit of 2008, which took place at Teagasc Atherry in June. The theme of the event was: 'Building sustainable farming and rural businesses for the future.'

The event was held in conjunction with 'BioEnergy 2008', jointly organised by Sustainable Energy Ireland, COFORD and Teagasc, which aimed to promote the use of solid biomass and raise awareness across all sectors, from landowner to end user, of the many uses and advantages in growing, harvesting and using wood fuels and energy crops for energy generation.



Children enjoying the mini-catchments model at 'Farmfest 2008'. The Agricultural Mini-Catchment Programme will evaluate the effectiveness of the National Action Programme mitigation measures, which implement the Nitrates Directive. A number of intensively farmed mini-catchments on a range of contrasting soil types will be established in partnership with stakeholders.

BIOTRACER European conference

The second General Meeting of the participants of BIOTRACER, an EC-funded project focusing on traceability of pathogens along the food chain, was held in Dublin from July 1 to 4. From an Irish perspective, the project is focusing on *Listeria monocytogenes* in farmhouse cheese. The meeting was organised by Dr Kieran Jordan, Moorepark Food Research Centre (deputy co-ordinator of the project).



Professor Martin Wagner, University of Vienna, making a presentation at BIOTRACER, with the International Advisory Board members (seated) and Dr Panos Skandamis (University of Athens), listening attentively.

Grange beef open day



Donagh Berry is pictured speaking to attendees at the Grange beef open day about beef cattle breeding.

Growing and utilising grass more efficiently, and breeding higher quality beef animals, were just two of the critical steps to improve profit on drystock farms outlined at the Teagasc beef open day in May.

National Soft Fruit Conference



The National Soft Fruit Conference 2008 featured a visit to Kearns' strawberry farm, Enniscorthy, Co. Wexford. Pictured are: Denise Kearns; Eilish Kearns; Jim Kearns; Susan Kearns; Dr Eamonn Kehoe, Teagasc Soft Fruit Specialist; and, Noel Kearns, with the first strawberries of the 2008 fruit season.

The strawberry industry in Ireland is worth close to €30 million annually, and is one of the areas of commercial horticulture that is expanding rapidly. Teagasc researcher, Dr Eamonn Kehoe, told a conference in County Wexford that the industry could grow to be worth up to €50 million in five years time as consumer demand increases due to higher disposable incomes and a huge interest in eating healthy foods.

He was speaking at the Teagasc National Soft Fruit Conference in Enniscorthy, Co. Wexford. The conference was officially opened by the Minister for

Horticulture and Food, Trevor Sargent, TD. Results from research trials carried out at Teagasc, Kinsealy Research Centre were presented, which demonstrated a doubling of yields, increased timing of crop production, and increased fruit quality.

Eamonn Kehoe said: "Growers are now using the information gleaned from trials in Kinsealy with very profitable success; achieving increased yields by as much as 100% and substantially reducing the importation of strawberry plants from countries where plant disease risks are always very high".

Food biotest facility

The Teagasc Authority has approved the development of a food biotest facility at Moorepark that will provide animal trial facilities in support of scientific validation for health promoting properties of food and food components. Teagasc is leading major new initiatives in research on food and health under its new 'Vision' programme. A total of €15m is being invested in new functional foods/nutraceutical laboratories, the food biotest facility, and equipment at Moorepark and Ashtown Food Research Centres. The additional research laboratories at Moorepark are under construction while the contract for the laboratories at Ashtown has been approved.

The last piece of the equation is the food biotest facility, which will assist both the researchers and the food industry to carry out trials that will support the scientific validation of health claims on functional food and bioactive food components.

The ambition for the centre is to have new products that are fully science based, developed in partnership with companies operating in Ireland. The recently established Enterprise Ireland-funded National Functional Foods Research Centre and the Marine Functional Foods Research Initiative will be the end users of the facility. Plans for the centre have been developed and risk assessments carried out. The facility will utilise the pig as a human model in feeding trials that will seek to understand the mechanisms by which functional foods impact on the digestive system, and provide clinical validation for the health benefits of functional foods. The pig has been recognised as a particularly good model for the human in studies connected to the alimentary tract.

This development has been widely welcomed by the Irish food industry and provides it with a new piece of infrastructure that will be an essential link to generating commercial opportunities for the Irish industry, based on first-class scientific research.

Lifetime achievement award



Dr Michael O'Keefe with his wife Rita at the award ceremony.

Dr Michael O'Keefe, recently retired senior researcher at Ashtown Food Research Centre, has received a 'Lifetime Achievement Award in Residue Analysis', from the EuroResidue Foundation in acknowledgement of his research contribution to this area. Michael, a graduate of UCD (BSc, PhD) has worked in food safety for 35 years. As a Teagasc employee, he contributed to international organisations such as the Food and Veterinary Office and the European Commission. He was also a member of the scientific committees of the Food Safety Authority of Ireland and CODEX. Michael has made a significant contribution to the safety of food produced in Ireland and the EU through his research. One of the highlights was research on the EU-funded project FoodBRAND, which identified a problem with nitrofurans in imported food and semicarbazide in baby food.

Michael also managed the residues laboratory at AFRC, one of six national reference laboratories responsible for surveillance of chemical residues in food to satisfy compliance with EU Food Law.

Michael's National Food Residue Database (NFRD), established in 2005 with FIRM funding, is used by the Irish food industry to assist production, processing and marketing of food. It has already been used as a marketing tool to promote Irish food from a food safety perspective and to demonstrate compliance of Irish products with regulations and customer specifications. This national resource is a comprehensive database of residues and contaminants in Irish food and is easily accessible through an interactive website (<http://nfrd.teagasc.ie>).

To assist users interpreting the data contained in the NFRD, an extensive library of information is accessible via the website. Michael's work is being continued by Dr Martin Danaher under a current project, which aims to expand the database.

EFSA experts

The European Food Safety Authority (EFSA) is inviting scientific experts to sign up to its new expert database. This database will be used to assist EFSA's Scientific Committee and panels in their risk assessment activities. For more, see: <http://tinyurl.com/4oyzr2>.

Researcher profile

Professor Paul Ross



Professor Paul Ross is Head of the Biotechnology Department at Teagasc, Moorepark Food Research Centre, Fermoy, Co. Cork. His main research interests are in food and health, particularly:

- antimicrobials and anti-infectives (applied and fundamental aspects);
- gut flora and gut health (cell signalling and probiotics);
- bacteriophage (phage therapy and starter cultures); and,
- functional foods and human health.

Professor Ross obtained a BSc in Microbiology/Biochemistry, and a PhD in Microbiology, from University College Cork. In 1989, he travelled to Wake Forest University Medical Centre, Winston-Salem, NC, USA, as a Research Fellow, remaining there until 1993, by which time he had attained the position of Adjunct Assistant Professor in the Department of Biochemistry. He returned to Ireland in 1993 to take up a position as Senior Research Officer in the Department of Dairy Quality, Teagasc, Moorepark, where he has held a number of positions since, leading to the Head of Department position. In 2003, he also became a Joint Programme Leader at the Alimentary Pharmabiotic Centre (a joint Teagasc–University College Cork initiative), and has been an Adjunct Professor at UCC since 2004. In 2005, he was awarded Scientist of the Year by the Alimentary Pharmabiotic Centre and in 2007 he was the recipient of The William C. Haines Dairy Science Award from the California Dairy Research Foundation in recognition of his significant research and development contributions to the dairy industry.

He has collaborated on numerous research projects in Ireland and abroad. He is a member of the editorial board of *Applied and Environmental Microbiology*, the National Sub-Committee on Novel Foods and GMOs (Food Safety Advisory Board), the American Society for Microbiology, the Society for General Microbiology, and the Glanbia Scientific Advisory Committee. He is also an *ad hoc* member of the European Food Safety Agency Committee on Genetically Modified Microorganisms. Professor Ross has given numerous presentations nationally and internationally. He is an external examiner of PhD theses in Ireland, the UK, the USA, Norway, Finland and the Netherlands, and an *ad hoc* reviewer of many scientific journals. He has amassed approximately 200 peer-reviewed publications to date, and has also been involved in 13 patent applications, most recently for Thuricin CD, an antimicrobial for specifically targeting *Clostridium difficile* (patent filed November 2007).

Denitrification workshop



Participants in the 'Advancing methods for measuring denitrification in terrestrial and aquatic systems' workshop in Baltimore, US, which was attended by Teagasc's Dr M. Ibrahim Khalid.

Dr M. Ibrahim Khalil of Teagasc Environmental Research Centre, Johnstown Castle, participated in a workshop entitled: 'Advancing methods for measuring denitrification in terrestrial and aquatic systems', with an invitation from the Denitrification Research Coordination Network of the National Science Foundation, USA. The workshop was held at the University of Maryland Centre for Environmental Science, Baltimore, in May. In addition

to taking part in hands-on training and discussion on the recent methodical advancements of denitrification studies in soil, groundwater and estuaries/oceanic ecosystems, Dr Khalil has proposed a new, simple method using He/O₂ mixture to measure denitrification end products - nitrous oxide and di-nitrogen - which is under development at Teagasc, Johnstown Castle Environment Research Centre.



RAMIRAN award

First prize was awarded to Conor Dowling, a UCD Walsh Fellow based at Johnstown Castle Environment Research Centre, for his poster presentation on: 'The effect of application technique and climate on ammonia emissions

from cattle slurry', at the 13th International Conference of the Network on Recycling of Agriculture, Municipal and Industrial Residues (RAMIRAN), which took place in June in Albena, Bulgaria. Conor is supervised by Dr Tom Curran (UCD) and Dr Gary Lanigan (Teagasc, Johnstown Castle).

New soil database website launched

A new National Soil Database website (NSDB) has been launched as part of a joint project between Teagasc and the EPA. The new website, available at <http://erc.epa.ie/nsdb/>, includes an interactive map interface, which allows all the data compiled during the soil sampling campaigns to be viewed. Clicking on a point on the map provides access to the data relevant to that sampling site. A sample can then be requested by completing the form available online. Requests will be reviewed by an advisory committee, composed of the National Soil Database Project Partners and international experts.





Dr Gale Buchanan (right) pictured with Professor Gerry Boyle, Teagasc Director, with a plaque to mark the contribution of the American Government to the establishment of Teagasc's predecessor, An Foras Talúntais.

The big picture

Dr Gale Buchanan from the United States Department of Agriculture gave a lively talk on the importance of research to the development of agriculture at the recent Foresight 2030 Conference in Dublin Castle. CATRIONA BOYLE reports.

Dr Gale Buchanan, the Under Secretary for Research, Education and Economics in the United States Department of Agriculture (USDA), gave the keynote address at the Foresight 2030 Conference. His talk focussed on the strategic role of agriculture and food research institutes – past, present and future.

Dr Buchanan said that agriculture has played a significant role in the history of both Ireland and the United States. He pointed out that agriculture has been the foundation industry of civilisation throughout the world and today still undergirds all other industries today.

Dr Buchanan explained how the appliance of science to agriculture is a relatively new phenomenon, dating back about 150 years, but that applying science and education to agriculture in Ireland, the US and elsewhere has improved human health and environmental quality.



Agriculture has been so productive and done so well, people have kind of lost sight of how fragile it really is. It's as if we have lost track of the fact that food is linked to agriculture, which is linked to human survival.

"Science and education have led to improved human nutrition, safer food, improved animal health, better soil management, improved use of fertilisers, enhanced varieties of crops, advanced control of insects, diseases and weeds, and superior methods of harvesting, storing and transporting farm products.

"The result is food security for millions of people. From 1950 to 2000, the world population grew from 2.5 billion to six billion; however, food production grew even faster and today proportionately fewer people are chronically undernourished. We have even more daunting challenges ahead, as the world population continues to climb – to nine billion by mid-century – and more people raise their expectations for improved quality of life."

Investment in research

Dr Buchanan said that public investments in agriculture research have, unquestionably, made life better for millions of people throughout the world. He added that few areas where public money has been invested have performed better. For example, the USDA Economic Research Service has reported a consistent return on investment in agricultural research of 20-60%. He added that Teagasc Director Professor Gerry Boyle's analysis of the return of investment for Irish agricultural research on seven projects ranged from 9-95%.

"Agricultural R&D investment is one of the prime drivers of growth in agricultural productivity. The rates of return in developing countries averaged 50%, while rates of return averaged 45% in Organisation for Economic and Co-operative Development (OECD) countries. The achievements in productivity and rates of return are significant and have validated our agricultural science system that exists today."

Dr Buchanan emphasised that this system will not be here if we do not meet some of the world's most urgent challenges for the 21st century, namely: developing sustainable energy as well as sustainable agricultural systems; improving water quality and availability; addressing the causes of and understanding global climate change; and, continuing to assure food security as well as food safety.

"Agriculture and agricultural science can play a major role in helping to meet all of these challenges. Now is the time for more research and more collaboration and co-operation on the part of the international agricultural research community."

Water availability and quality

Dr Buchanan said that water availability and quality is another challenge for agriculture. He explained that in some parts of the world depleted ground water supplies, degraded water quality and adverse climatic conditions are reducing the quality and the quantity of fresh water.



Agricultural research institutions must be carefully nurtured and supported to ensure that they have the resources for success. Their success ensures our survival.

"Agriculture is the single greatest water consumer in the world. Globally, farmers are irrigating five times more land than at the beginning of the 20th century. Today, irrigated agriculture supplies about 40% of the world's food. Water resources in many parts of the world are already constrained, and now more than half the world's population lives with water scarcity. "Additionally, the Food and Agriculture Organisation (FAO) estimates that in order to feed the world's growing population, food production needs to grow at 1.4% a year by 2030. About half of this growth would have to be generated from irrigated agriculture. Yet water use remains well below technical efficiency. Agricultural science and technology can help to increase crop yields with less water, improve water use efficiency in agriculture, offer better tools for conservation and provide early warnings of drought. Research can also develop new plants that require fewer inputs, including water.

"As we engage in biomass production for fuels, we must employ our agricultural science capacity to meet this demand with minimum impact on the world's water supply."

Sustainable energy

Dr Buchanan said that achieving greater energy security for all people on this planet requires that all potential energy sources be considered.

"This includes, in addition to fossil sources, geothermal, hydro, nuclear, solar, wind, hydrogen and biomass. While each of these sources has considerable potential in some situations, the ultimate energy source is the sun – at least for the next four to six billion years! Calculations show that sufficient energy reaches the earth from the sun in one hour to provide our energy needs for one year. The challenge is to capture it."

Speaking about biomass, he said that its use as an energy source is not without challenges.

"Energy is a vital national security issue for all nations. It is also vital to the world's economic security. Because markets are global, energy market disturbances affect us through prices and other economic linkages. There are several other indicators pointing to the need for sustainable energy security. First, oil is getting harder to find. Established oil and gas fields are maturing, or they are in difficult-to-access areas, such as the Arctic, or in deep ocean waters, or in politically unstable regions of the world. Secondly, tight supplies are making prices higher and more volatile. Throughout the world, people are seeking a higher standard of living. This is a significant driver in creating greater demand for energy, and thereby driving prices up worldwide."

He said that agriculture and agricultural research could make a big difference towards improving the sustainability of bioenergy production.



Agriculture is the single greatest water consumer in the world ... Water resources in many parts of the world are already constrained, and now more than half the world's population lives with water scarcity ... As we engage in biomass production for fuels, we must employ our agricultural science capacity to meet this demand with minimum impact on the world's water supply.

"Research can develop new non-food energy crops that use fewer inputs and that can be grown sustainably on marginal lands, develop better conversion methods that will enable the wide-scale use of cellulosic biomass for ethanol production, and find new ways to conserve energy on the farm.

"However, bioenergy is not the 'end-all' solution to the world's energy problem. Meeting the world's future energy needs will involve developing a variety of alternative energy sources. Finding a sustainable solution for energy also means improving energy efficiency and conservation everywhere energy is used."

Climate change

Dr Buchanan pointed out that agriculture is both vulnerable to environmental change and can also affect some of the factors contributing to these changes. He said that it has long been established that short-term regional environmental changes, such as seasonal drought and late freezes, are primary causes of variation in crop yields and livestock productivity.

He stressed that research needs to address the likelihood that agriculture will be affected by long-term global scale changes such as human impacts on the Earth's atmosphere.

"Currently, it is estimated that agriculture accounts for one-fifth of the annual increase in human-induced greenhouse warming. Much of this is due to methane and nitrous oxides; agriculture produces about 50% and 70%, respectively, of human-induced emissions of these gases. Agricultural research must also investigate the potential for agriculture to play a role in mitigating the factors affecting environmental change, for instance by sequestering carbon in soil."

He told delegates that President Bush has recently announced a new national goal for the US: to stop the growth of US greenhouse gas emissions by 2025. "To reach this goal, the US will pursue an economy-wide strategy that includes energy legislation that specifies a new fuel economy standard of 35 miles per gallon by 2020, and requires fuel producers to supply at least 36 billion gallons of renewable fuel by 2022.

"This should provide an incentive for shifting to a new generation of fuels like cellulosic biofuels, which will reduce concerns about food prices and availability, as well as about the environment. The President also mandated new objectives for the coming decade to increase the efficiency of lighting and appliances, and other

conservation measures. Taken together, these landmark actions will prevent billions of metric tons of greenhouse gas emissions from entering the atmosphere."

Food security and safety

Dr Buchanan said that while agricultural research has made enormous strides towards improving food security for millions, 800 million people currently face chronic hunger.

"To meet the goal of food security, agriculture productivity must be accelerated in areas where hunger and malnutrition are worst. Agricultural science and technology offer some of the most effective tools to raise agricultural productivity. Current and emerging technologies have the potential to increase farm yields, improve the nutrient content of foods, deliver inexpensive and edible vaccines, and improve distribution.

"Whatever the technology, it must be appropriate and accessible. Increased agricultural productivity can: increase incomes; enable poorer countries to participate in global markets; reduce hunger and poverty; and, improve quality of life. By fighting hunger, you also fight poverty and the source of much of the conflict in the world today."

Dr Buchanan said that as agriculture and food become a more global enterprise, it is imperative that all nations have confidence in the food they eat as well as all those food products that enter commerce.

"Nations must work together to develop international standards for food safety that are based on sound science. Teagasc and USDA's Agricultural Research Service have a long-standing relationship working together on food safety research that is a model for international co-operation."

Global response

Dr Buchanan said that all the challenges he spoke about are global in scope, requiring a global response.

"I don't believe that I'm making an overstatement when I say that the well-being of our civilisation and the fate of mankind on this fragile globe rests on the success of the agricultural research and education enterprise. The US Agricultural Research Service and Teagasc, along with our agricultural universities and other such institutions around the world, have the responsibility of ensuring our success.

"Our work will never be done. The world's demand for food will continue to adapt, overcoming our efforts against it, and new threats to our food system will continue to emerge."

Dr Buchanan quoted a recent article from the *New York Times* where Jan E. Leach, a plant pathologist at Colorado State University, said: "Agriculture has been so productive and done so well, people have kind of lost sight of how fragile it really is. It's as if we have lost track of the fact food is linked to agriculture, which is linked to human survival".

"We must not let that happen," said Dr Buchanan. "Agricultural research institutions must be carefully nurtured and supported to ensure that they have the resources for success. Their success ensures the future of our survival."



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Foresight 2030

Under the shadow of an uncertain global economy, the launch of the Teagasc Foresight 2030 document, and its receipt at the launch conference, brings a positive outlook to the future of the Irish agri-food industry.

Teagasc's Foresight 2030 exercise began in December 2006 with the aim of identifying the research, innovation and support priorities for the next quarter century for Ireland's agri-food sector. Stakeholders were engaged throughout the process and the final document contains a shared vision and a strategy for the future.

A number of driving forces were reviewed to determine their long-term impact on the sector, including international factors such as EU policy developments, WTO negotiations and climate change, and local changes, such as demographic trends.

The report envisages agriculture and food production as part of a wider 'bioeconomy' in 2030, which embraces all of the sectors exploiting natural resources and bio-processes to generate products and services, jobs and income. The vision for this bioeconomy is that it will become central to Ireland's developing knowledge economy and rest on four sectoral pillars, including traditional sectors and new and emerging ones. A successful agri-food sector and rural economy will enhance the quality of life for everyone, as well as contributing to economic prosperity.

The four pillars of this future knowledge-based bioeconomy are: food production and processing, value-added food processing, agri-environmental products and services, and energy and bio-processing.

Food production and processing

The food production and processing pillar encompasses the farmers and growers who produce food for human and animal consumption, plus the processors engaged in adding value to those raw materials. Teagasc's long-term goal for the pillar is to provide support for science-based innovation so that it is internationally competitive, profitable, sustainable, maximises added value, and contributes to long-term food security, while providing attractive career opportunities for young entrants.

Over the next number of years, Teagasc's programme for the production sector will continue to focus on livestock, crops, environment and rural economy, on the nutrition, breeding and health of animals and crops, and on reducing environmental impacts, particularly with regard to water and air quality. Measures to support food processors will reflect our belief that, in the medium term at least, milk production will increase, beef output will remain relatively static, and energy and commodity prices will remain higher than the historic levels. It will be set in the context of a commodity sector that achieves global competitiveness through efficient and sustainable processing incorporating scale consolidation, the most energy efficient technologies and maximum recycling of by-products. The sector is self-reliant in core process technologies for mass market products.



Pictured at the launch of Teagasc Foresight 2030 are (from left): Dr Tom O'Dwyer, Chairman of the Teagasc Authority; Brendan Smith, TD, Minister for Agriculture, Fisheries and Food; and, Professor Gerry Boyle, Director of Teagasc.

Value-added food processing

Fast moving, innovative and international, this pillar is continually adopting and improving the technologies used for production, processing, preparation and distribution. Considerable attention is also given to intangibles such as patents, brands, provenance and traceability. The main goal is to maximise the value added through post commodity, market-led product innovation in food ingredients and consumer foods from the dairy, meat and cereal sectors. Dairy companies and specialised ingredient manufacturers will be innovative in the development and customisation of ingredients for formulated foods from a variety of dairy and non-dairy sources. The sector will provide leadership in functional food markets by developing bioactive ingredients and forming strategic alliances with research institutions and multinational food and pharma partners. The industry will respond to meet changing consumer needs in taste, convenience and health concerns and produce a more diverse range of dairy, meat, drink and cereal-based products for consumers around the world.

Agri-environmental products and services

The goals for this pillar are to: equip farmers with the knowledge to deliver high levels of agri-environmental quality; provide evidence-based knowledge to support policymakers in designing, implementing and evaluating programmes; and, develop quantifiable agri-environmental measures targeted at spatial variation and different farming systems.



Members of the Stakeholder Panel at the Teagasc Foresight 2030 launch conference (from left): Mike Feeney, Executive Director, Enterprise Ireland; Olivia O'Leary, Moderator; Jackie Cahill, President, ICMSA; Dr Hugh Brady, President, Irish Universities Association Council; Padraig Walshe, President, Irish Farmers' Association; Catherine Buckley, President, Macra na Feirme; John Moloney, Group Managing Director, Glanbia; Professor Gerry Boyle, Director of Teagasc; and, Dr Lance O'Brien, Foresight Project Manager.

Energy and bio-processing

This pillar includes the forestry sector, farmers, resource managers and those who produce feedstock for energy and bio-processing.

Teagasc's forestry programme will help improve the quality and productivity of farm forests by developing a greater understanding of the interaction between site quality and growth. Teagasc will develop management and silvicultural intervention strategies to optimise the value of forests and quantify their contribution to greenhouse gas abatement. Teagasc will identify strategies for optimising both financial returns from farm forests and the area of farm forestry nationally and contribute to the development of strategies that will encourage forest tourism and agri-environmental products.

Biomass is a readily available and potentially carbon-neutral source for energy and biomaterials suited to a wide range of chemical, physical and biological uses. The development of this sector will give farmers more land use options and provide the country with an opportunity to address its energy security. Advances in conversion technology, plant genetics and biotechnology will generate new techniques for converting biomass into valuable end products such as fuels, 'green chemicals' and new products with high added value.

National and EU goals

Welcoming the report, Minister for Agriculture, Fisheries and Food, Brendan Smith, TD, said that its resulting vision of agri-food as a core element of a broader knowledge-based bioeconomy accords with national and EU goals for developing sustainable knowledge-based economies. "It also recognises the prime importance of pursuing new markets and promoting economic growth in an increasingly competitive market environment. This initiative will help strengthen the strategic capabilities of Teagasc and its relevance to its stakeholders enabling it to provide proactive leadership in this rapidly changing open market environment. Actions arising from this report will be important in facilitating the agri-food sector and the broader bioeconomy to take advantage of new opportunities and to meet the emerging challenges. The findings will also feed into the ongoing national policy debate."

Stakeholder comments

Key stakeholder representatives took to the main stage in a panel under moderator Olivia O'Leary during the Foresight 2030 conference.

Grass-based systems of production

A number of stakeholders referred to Ireland's competitive advantage drawing from its grass-based system of production. There were several meaningful contributions, with John Moloney, Group Managing Director, Glanbia, summing up the position well: "For the first time since 1984, we can see a position where the dairy sector can be expanded in this country; an industry which has an inherent natural advantage due to its grass-based systems. The challenge is to optimise these systems. Only 7% of global dairy products are traded internationally (560 million tonnes). Dairy demand in China is growing at 10%. Demand for dairy in the Middle East and Africa is growing at 3.5% and the average in the rest of Europe is 0.5%."

Education and prospects

The education of the farmers of the future and the development of farming as an attractive career option also featured prominently. Catherine Buckley, President, Macra na Feirme, said: "The report highlights the need to motivate the next generation ... we need to encourage them and give them the skill set, abilities and know how to drive the industry forward."

Research and sharing technologies

Research was agreed as playing a key role for the future and as requiring investment.

Padraig Walshe, President, IFA, observed: "The world has harvested over the last 20 years the investment that was put into research and development in the '60s and '70s. It is way past time to drive it forward again."

Dr Hugh Brady, President, Irish Universities' Association Council, made the point that we must follow our own Irish agenda: "If what we do in Ireland looks the exact same as what is being done in the UK and the US, we've got a problem. There are going to be times that we have to take risks and that is critical in an era of increasing accountability."

Minister Smith said that the report was timely. "Policymakers around the world are realising the importance of agriculture and natural resources generally as providing solutions to many of the key problems facing mankind, including challenges relating to energy and climate change. Some of these factors are also reflected in the current strong world market prices for many agricultural commodities. Hopefully, this is a sign of greater appreciation in the longer term of the cost and demand of producing foodstuffs."

The Foresight 2030 document is available for download on: www.teagasc.ie.



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The Teagasc Vision programme

As part of the Government's investment of €8.2bn in science, technology and innovation under the National Development Plan, the Teagasc Research Vision programme will help to place the agriculture and food industries as central to Ireland's economic prosperity in the future. The exploitation of the natural bioscience technologies in the agricultural and food areas is a central pillar of the Irish knowledge-based bioeconomy.

The pace of change in today's world is breathtaking. New challenges arrive, such as climate change, and before we can come to terms with that, others such as dwindling oil reserves and rising fuel prices emerge. Then an old problem that we thought was part of history re-emerges: food security. The modern consumer is extremely conscious of the impact of diet on health, while at the same time obesity is a growing problem in the developed world. The *Teagasc Foresight 2030* report identifies these as some of the most significant challenges facing the world in the early years of the third millennium. Together, they thrust agriculture and food production back into a critical role in the future security and prosperity of the world as we know it. Agriculture will develop into a much more knowledge-intensive industry, and will be a significant part of the knowledge-based bioeconomy. The government has recognised the critical role that the agri-food sector can and will play in transforming Ireland. In the National Development Plan, it has committed to significant investment in the sector and in agri-food research. The role of agriculture and food research will be more important than ever before as new, more complex, more challenging and far-reaching solutions are required. The Teagasc Vision programme is part of the plan to underpin the long-term science and technology needs of the agri-food industry.

The essential element of the Vision programme involves expanding the amount of the organisation's resources devoted to biotechnology, such that world-class competence in selected key areas will be established. In this regard, Teagasc is influenced by the conclusions of the Interdepartmental Group on Modern Biotechnology, that biotechnology has the potential to deliver major benefits to individuals and societies in areas such as healthcare, agriculture and environmental remediation. The programme involves a capital investment in new laboratories and facilities of €27m and an increase in scientific staff numbers of 30 in selected areas. In agriculture research, the biggest project is the new Animal Bioscience Centre, to be located at Grange. There are also investments in environment and land use, crop science, and economics and rural research. In food research, the programme has three elements: functional foods research related to obesity and colon cancer; a new research department focused on

nutraceuticals; and, a large animal facility for clinical trials using the pig as a human model. The achievement of a high level of integration within Teagasc, and with other national and international institutions, is an integral part of this proposal. Given the strategic national importance of the agri-food industry in Ireland, Teagasc must take up the challenge of developing a knowledge-based industry founded on a world-class research system, spearheaded by world-class researchers, carrying out research that is recognised internationally as being excellent. The Teagasc Vision programme will significantly increase Teagasc's capacity to deliver these solutions.



Animal Bioscience Centre

The Animal Bioscience Centre (ABC) is a major new initiative to expand Teagasc's capacity for bioscience research within its animal science research programme. The focus of research in the Animal Bioscience Centre will be firmly on increasing efficiency of production of quality milk and meat. Key topics will be:

- efficiency of conversion of feed to product;
- product quality;
- animal health and welfare; and,
- animal reproduction.

In general, the research will aim to:

- identify novel biomarkers that can be used in animal breeding programmes to supplement traditional selection procedures, and participate with animal geneticists in a research programme on whole genome selection using genome-wide dense-marker maps; and,
- gain a more fundamental understanding of nutrition, metabolism and physiology, which will give researchers in these disciplines significantly greater ability to optimise diets and management systems for the improvement of animal production, product quality, animal health and reproduction.

Where possible, the scientific findings from the research programme will be applied to industry, and where these relate to genetic control, the close links between Teagasc and the national animal genetic programme will be used to exploit these findings in the national interest.

The main resources available at the ABC will be state-of-the-art genomic and proteomic laboratories, as well as excellent laboratories for nutrition, physiology and animal health-focused analysis, and a modern facility for in-depth animal experimentation. The ABC will work closely with the existing animal centres at Grange (beef), Moorepark (dairy and pigs) and Athenry (sheep and cattle physiology). It will also collaborate closely with Irish and international partners.

Functional food research

Research on food for health is one of the central themes of the Vision programme. Development of functional foods is a key area of opportunity for Ireland's food industry and the overall goal of the food Vision programme is to generate and transfer scientific knowledge and intellectual property on bioactive food components to food companies. This mission is built on a strong existing foundation in the relevant sciences. The thematic areas selected for inclusion in these are obesity, gut health and nutraceuticals. Obesity is prioritised because of the opportunity to connect food product innovation to a major diet-related pandemic in western countries. Gut health relates to the importance of the gut microflora in human health and how food can 'programme' the composition of the microflora in a beneficial way. Gut microflora are increasingly being connected to obesity itself, but other key connections that are of primary interest are to elderly health and early infant development. Nutraceutical research embraces the discovery and development of biologically active components for use in functional foods, drawing on all food-acceptable sources including milk, plants and marine sources. Teagasc has an opportunity to be a pioneer in this area, which has been neglected somewhat in Ireland. Specific goals of the food Vision research programme include:

- discovery and development of bioactive components from animal, plant and marine sources that have potential as bioactive functional food ingredients;
- development of biological techniques required for the discovery and validation of food bioactives;

- provision of the scientific and clinical validation necessary to support health claims on functional foods;
- development of innovative technology for the incorporation and delivery of bioactives in the food matrix; and,
- engagement with food companies, including high-tech SMEs, to ensure maximum effectiveness in technology transfer.

Delivery of the food Vision programme will be challenging and will involve significant staff and capital investment, including 10 new staff members, a large animal facility for clinical trials, extension to existing laboratories at Moorepark and a new nutraceutical laboratory building at Ashtown.

Environment and land use

The research programme at Johnstown Castle focuses on researching the scientific and technical basis for the development and practice of environmentally sustainable farming. The challenges of water quality, soil quality, climate change, and nutrient use efficiency are immense. As part of the Vision programme, Teagasc has invested in six controlled environment growth chambers and state-of-the-art laboratory equipment for soil analysis, and is seeking to strengthen the soils research staff by appointment of a senior biogeochemist. The other key area to be strengthened as part of the Vision programme is biodiversity, a key component of the public goods supplied by agriculture.

Crop science

In recent years, Teagasc has made significant investment in capital and human resources devoted to crop biotechnology at Oak Park, with new state-of-the-art laboratories. This investment will be consolidated in the Vision programme. In addition, the potential to diversify agricultural production into non-food markets needs to be exploited urgently, and this is a key area to be developed in the Vision programme. In the short term, use for renewable energy is the most promising option, given the need to comply with EU Directives on global warming and transport biofuel production. In the longer term, crops and technologies for the production of fibre, biodegradable plastics and a range of other chemicals will become more feasible and more in demand. New facilities and staff will be provided in this area.

Economics and rural research

The mission of the Rural Economy Research Centre is to produce high quality economics and social science research and policy advice to improve the competitiveness and sustainability of Irish agriculture, and to enhance quality of life in rural Ireland. The centre has expanded its research staff significantly in recent years. As part of the Vision programme, the provision of new office facilities is underway at present. Additional new staff will join the centre to strengthen the programme in areas such as environmental economics.



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Trends in beef carcass classification

GERRY KEANE, Teagasc Grange, reports on the latest trends in beef carcass classification.



Previously, trends in beef carcass grades from the mid '80s to the late '90s have been described (Keane, 1999). In the early years of that period, carcass conformation of steers and heifers improved considerably before declining to initial values by the end of the period. Carcass fat class increased consistently throughout the period. These changes in carcass classification values could not be explained by changes in breed composition or carcass weight. It is now timely to look at recent trends, particularly in view of the change to the use of machine classification in 2004. As 2004 was the transition year, it is arguable whether the results for that year should be considered manual or machine values. For the purposes of this evaluation, the 2004 results are considered manual, but from the beginning of 2005 the results are considered to be machine values, even though it is likely that machines were not fully operational in all meat plants from that date.

Steer and heifer classification

Mean steer and heifer carcass conformation and carcass fat classes for 2000 to 2007, inclusive, are shown in **Figure 1**.

Conformation

Over the eight-year period there was a small improvement (0.04 for steers and 0.22 for heifers) in average conformation class. In the first three years of the decade, carcass conformation changed little for either gender. Then in 2003 and 2004, there was an increase in the better grades and a decrease in the poorer grades, with the effect being greater for heifers than steers (**Figure 2**). After 2004, there was a small deterioration in the better grades and a corresponding increase in the poorer grades. For the three years (2005 to 2007, inclusive) since the introduction of the machines, the combined better grades (U + R) accounted for 51% of steer carcasses, compared to 56% for the preceding three years. The

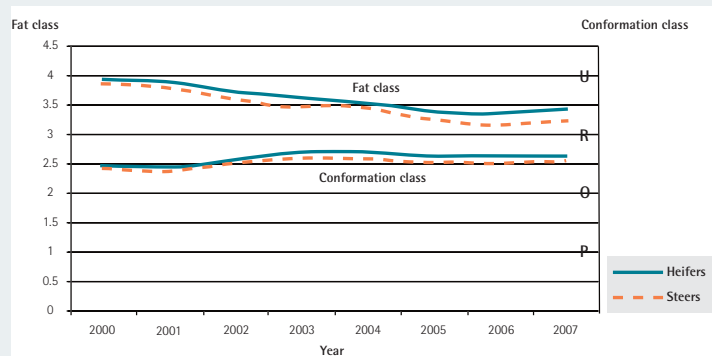


FIGURE 1: Mean carcass conformation and carcass fat classes for steers and heifers (2000-2007).

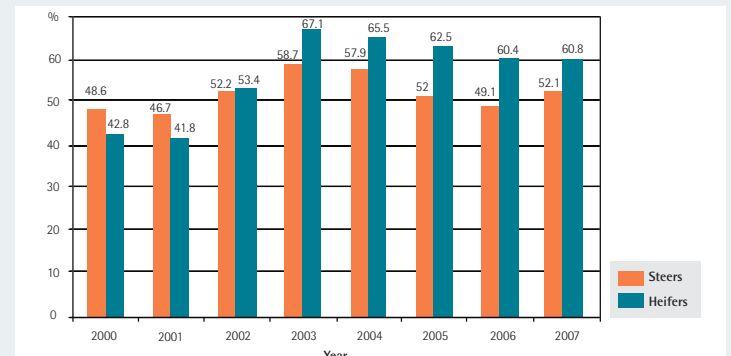


FIGURE 2: Proportions of carcasses in the better conformation classes (U + R) for steers and heifers (2000-2007).

T Livestock

corresponding values for heifers were 61% vs. 62%. Thus, while there has been a slight reduction in the proportion of the better conformed steer carcasses since the introduction of machine classification, this needs to be put into the context of the relatively large improvement in the preceding years. Interestingly, in the first two years of the decade there was a higher proportion of heifer than steer carcasses in the better conformation classes. In 2002 the proportions were equal for the two genders, but since then there has been a higher proportion of steer carcasses in the better conformation grades.

It is often claimed that the proportion of best conformation (E and U) grade carcasses has declined since the advent of machines. There is no evidence for this. The mean proportion for steers was 6.5% for the three years from 2005 to 2007, inclusive, compared with 6.4% for the previous three years (2002 to 2004, inclusive). The corresponding values for heifers were 5.8% and 6%.

Differences between steers and heifers in mean carcass conformation were small but the heifer population would have had few pure dairy animals, which have poorer conformation.

Fatness

Unlike conformation, where any changes have been rather small, there have been relatively large changes in fat class since the beginning of the decade. However, it is unclear whether any of this can be attributed to the move to machine classification. From 2000 to 2007, average fatness of steers and heifers decreased by 0.63 and 0.5 of a class, of which 0.43 and 0.37, respectively, had occurred by 2004. In 2000, only 20% of steer carcasses were in fat classes 1 to 3 (Figure 3). This increased to 50% in 2004 and to 65% in 2007. The corresponding values for heifers were 18% in 2000, 40% in 2004, and 51% in 2007. There is little evidence that the fatness trends were influenced by the introduction of machines for either steers or heifers.

Cow and cattle numbers

There were declines of 5% and 7% in total cow (2.31 to 2.21m) and cattle (6.33 to 5.90m) numbers, respectively, over the eight-year review period, with a small increase in beef cows as a proportion of total cows (50 to 50.7%). While an increase in the proportion of beef cows should be positive for carcass conformation and leanness, the increase was so small that it is difficult to attribute any of the carcass classification changes to it.

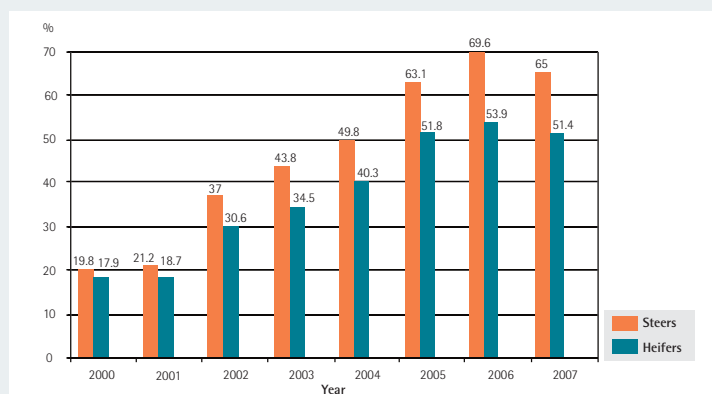


FIGURE 3: Proportions of carcasses in the lower fat classes (1 + 2 + 3) for steers and heifers (2000-2007).

Live exports

Other than in 2000, when they were highest (18%), and in 2001, when they were lowest (5%), live exports as a proportion of total cattle disposals ranged from 7% to 12%. As live exported animals are predominately <6 months of age, the effects on carcass grades should be evident about two years later. Thus, the high live exports in 2000 (assuming they were predominantly suckled weanlings) should have had an adverse effect on carcass grades in 2002 (all else being equal), but this was not so. Neither was there any great evidence of an improvement in carcass grades in 2003 following the low proportion of live exports in 2001. From the data available, therefore, it is not possible to attribute the observed national carcass classification trends to the effects of between-year differences in live exports.

Breed composition

Since there are differences between breed types in carcass classification values, trends over time in carcass classification could be attributable to changes in breed composition. Generally, there has been little change in breed composition during the review period. The proportions of the national calf crop sired by dairy, early maturing beef breeds, and late maturing beef breeds (Figure 4) were identical for 2000 and 2006 (the last year for which data are published). In between, the proportion of late maturing beef-sired calves was quite consistent but, in the early years of the decade, the proportion of dairy calves increased, while that of early-maturing beef calves decreased. Thus, the 2003 and 2004 calf crops had more dairy and fewer early-maturing beef calves than earlier or later years. This might explain the slightly poorer carcass conformation in 2005 and 2006 but, if so, some increase in fat class would also be expected and this was not observed.

Carcass weight

Changes in carcass weight would be expected to affect carcass classification because conformation improves and fatness increases with increasing weight, all else being equal. From 2000 to 2004, carcass weight remained fairly constant (Figure 5), but it has since increased for both steers (20kg) and heifers (19kg). This should have led to better carcass conformation and a higher carcass fat class in the last three years. As indicated already, this was not observed, and both carcass conformation and fat class of both steers and heifers remained essentially constant over this time.

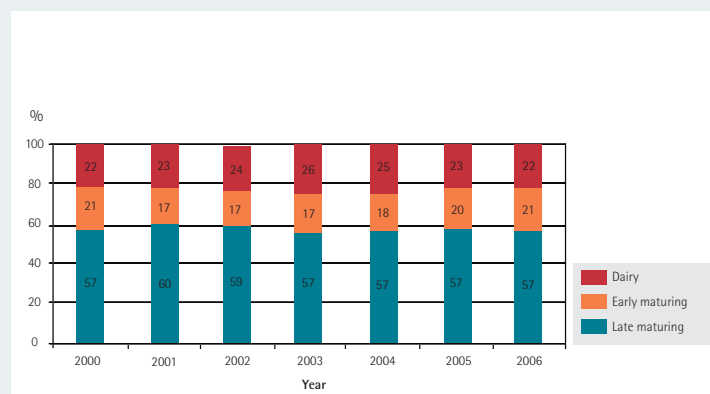


FIGURE 4: Proportions of late maturing, early maturing and dairy sired calves (2000-2006).



There have been relatively large changes in fat class since the beginning of the decade.

Summary

Over the eight-year period from 2000 to 2007, carcass conformation of steers improved slightly to 2003 and then declined slightly, with the result that it was little different in 2007 to what it was in 2000. Heifer carcass conformation followed a similar trend but the changes were somewhat greater, with the result that in 2007 carcass conformation was 0.22 of a class better than in 2000. Carcass fat class decreased consistently over the eight years and was 0.63 (steers) and 0.5 (heifers) of a class lower in 2007 than in 2000. There did not appear to be any relationship between carcass classification values and the proportions of beef and dairy cows, the level of live exports, the breed composition of the cattle population, or mean carcass weight. There was also little evidence of any effect of the change from visual to machine classification.

This research is funded by the Teagasc Core Programme.

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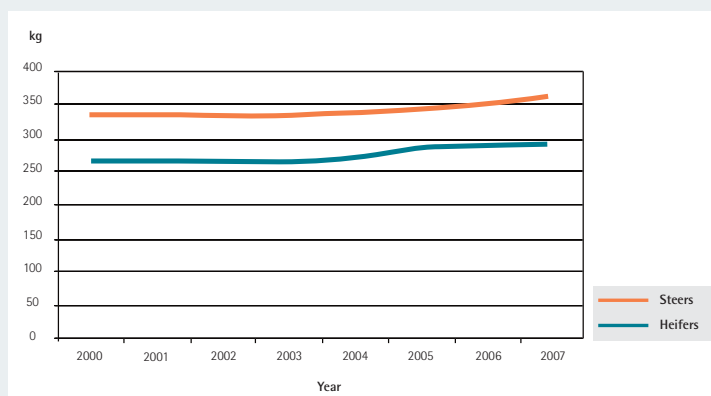


FIGURE 5: Mean carcass weights for steers and heifers (2000-2007).

Dairy herd health

Researchers at Moorepark Dairy Production Research Centre have recently started a new herd health programme, which aims to prepare Irish dairy farmers for the biosecurity challenges of herd expansion.

With EU milk quotas due to end in 2015, and world demand for dairy products outstripping supply, Irish dairy farmers are preparing to expand their dairy herds to avail of the opportunities this new market will present. A recent Teagasc study estimated that 50% of dairy farmers intend to expand their dairy enterprise by 10-15%, and that a 40% increase in milk production is achievable through increased stocking rates, animal production and greater specialisation. The scale of the dairy enterprise was identified as one of the major factors influencing these variables. The availability of dairy replacement heifers to upscale will be the first limiting factor to expansion in the post-quota era. This is reflected in the current high prices for such stock. However, a Teagasc SWOT analysis has identified that with this upscaling comes a threat to herd health. Given our current national disease status, farmers, vets, advisers and the dairy industry will need to address the biosecurity risks of herd expansion. Infectious diseases that present a threat to expanding herds include bovine viral diarrhoea (BVD), Johne's disease and salmonellosis, among others. In addition, the current somatic cell count and clinical mastitis status of our dairy herds present a real challenge for the larger dairy herds of the future. In order to address these issues, two new herd health research projects have commenced at Moorepark, which will address the knowledge gaps constraining progress towards better understanding and control of these economically important infectious diseases. Two new veterinarians have been employed to work on these projects. One project is focusing on mastitis and milk quality issues, and the other is focusing on infectious diseases. These are collaborative projects with the Centre for Veterinary Epidemiology and Risk Assessment in UCD, the Department of Agriculture, Fisheries and Food, and the University of Wisconsin in the US, among other national and international partners.

Biosecurity on dairy farms

Biosecurity refers to the prevention of disease entry (bioexclusion) and spread (biocontainment) on a farm. The most recent study to have examined aspects of biosecurity on Irish dairy farms was carried out over a decade ago. The attitudes, behaviours and actions of dairy farmers, their veterinarians and agricultural advisers in relation to biosecurity have not been documented since then. With the impending expansion of the national dairy herd, it is essential now to carry out such a study. Such a study will raise awareness of biosecurity and its benefits, and



Biosecurity refers to the prevention of disease entry (bioexclusion) and spread (biocontainment) on a farm.

orientate agricultural stakeholders towards preventive rather than curative animal health strategies. Input is required from all contributors to dairy herd health in order to establish the awareness of biosecurity and, more importantly, to determine the likely future attitudes of these sectors to the concept of on-farm contingency planning using biosecurity. The data generated in this study can be used to benchmark the uptake of biosecurity strategies in future studies. The first task in this new research project is to conduct national biosecurity questionnaire surveys of dairy farmers, their veterinarians and agricultural advisers. The first of these surveys, of Teagasc Business and Technology (B&T) dairy advisers, has been successfully completed. Preliminary results highlight an excellent awareness of the importance of biosecurity in minimising disease on farms among Teagasc dairy advisers. Only a minority of advisers (less than 15%), however, stated that dairy farmers regularly request biosecurity advice from them.

Currently there are no data available on biosecurity practices on Irish dairy farms.

Infectious disease prevalence

The prevalence of the regulatory infectious diseases (e.g., brucellosis and tuberculosis) in Irish dairy herds is known and monitored closely by the Department of Agriculture. However, there are no recent national data on the prevalence of the non-regulatory infectious diseases in Irish dairy herds. Recent diagnostic developments, coupled with the use of pooled blood, ear notch and bulk tank milk sampling, now enable screening of large numbers of herds. Hence, a second aspect of this herd health project will be to carry out national serosurveys to benchmark the prevalence of the economically important non-regulatory infectious diseases. Such diseases include BVD, salmonellosis, leptospirosis, Johne's disease, IBR and neosporosis. Emerging diseases, such as mycoplasmosis, may also be included. In addition to estimating their prevalence, the risk factors associated with disease occurrence will be assessed through biosecurity risk profiling. The economic impact of such diseases on herd production, fertility and health will also be quantified to allow identification of key performance indicators in relation to herd health on Irish dairy farms.



Footbaths are an effective biosecurity measure that can be employed on all farms to reduce the risk of disease spread.



A team-based approach to mastitis control should reduce the requirements for mastitis antibiotic therapy.

Mastitis control

Producing high quality milk is every dairy farmer's goal; a goal that is made all the more challenging in an environment of increasing demands from the consumer and, consequently, the milk processing companies, thereby increasing input costs and reducing available time and labour. In Ireland, average bulk tank somatic cell counts (BTSCC) have risen annually by 5,000/ml since the start of this decade. Farmers are losing financially through penalties imposed due to milk quality issues, such as somatic cell count (SCC), bacterial content and residues and direct costs associated with clinical mastitis cases. There are also indirect costs, such as labour, culling, mortality, etc. Lost opportunities also exist when cows are not maximising potential production as a result of subclinical disease.

"MilkMoney"

At present, the farmer may seek help and advice on milk quality issues from several sectors of the industry, but with very little collaboration between these advice sources. Each of these stakeholders has particular strengths and skills; combining these skills on a team could maximise their impact. The idea of using a team-based approach to solving milk quality issues is one that the University of Wisconsin has explored with great commercial success. Their "MilkMoney" programme has been instrumental in defining clear milk quality goals, creating clear action plans and adopting best management practices.

The Teagasc team-based milk quality/mastitis control plan is presently being designed at Moorepark. It is based on some of the key concepts of the US approach, namely team-based, involving realistic targets, identifying strategic management changes, accountability and regular re-assessment. It will commence with a pilot programme involving 20 farms, to see how the programme works in an Irish situation. The teams will be made up of Teagasc advisers, manufacturing outlet milk quality advisers, vets, milking machine technicians and the host farmer. Ultimately, however, it will be the farmer's choice as to who he/she wishes to include on their working team. Preparation for the pilot will include training workshops for all parties involved aimed at improving the skills required to work through milk quality issues on farm, and team-building exercises. Farmers are currently being recruited for participation in the pilot programme, which will run for a period of nine months.

The idea of using a team-based approach to solving milk quality issues is one that the University of Wisconsin has explored with great commercial success.

There will also be the involvement from a social scientist who will study the dynamics of the teams, look at why some teams may have more success than others, and also look at farmers' response to the project. The purpose of this research is to study what influences the uptake of advice or suggestions, and whether we as advisers can present knowledge in a more 'palatable' fashion that would allow easier uptake by farmers.

The findings from these research projects will underpin future voluntary herd health accreditation or HACCP programmes on the Irish dairy farms of the future.

Funding for these research projects is provided by Dairy Levy research funds.

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Tackling dairy cow welfare issues

LAURA BOYLE and GABRIELA OLMOS describe their work on elucidating the advantages of grass-based dairy systems from an animal welfare perspective, thereby increasing the competitiveness of the dairy industry.

Dairy farming is relatively free of constraints imposed by animal welfare legislation, but this is likely to change in the future. Currently, the European Food Safety Authority (EFSA) is compiling a report on the welfare of dairy cows. According to Professor Don Broom, Chairman of the EFSA dairy cow welfare working group, it is likely that an EU Directive on the welfare of dairy cows will follow. Such legislation could constrain the way in which cows are fed, managed and housed. Additionally, aspects of genetic selection could be restricted and pressure is likely to be placed on milk producers to allow cows access to pasture. In most EU countries, cows are housed all year round, whereas in Ireland cows are at grass for between six and 10 months of the year. In this respect, the Irish dairy industry could have a significant advantage over its European counterparts if legislation insisting on access to pasture is enforced. However, this does not mean that we can be complacent when it comes to dairy cow welfare, because cows in pasture-based systems can still suffer poor welfare. In light of future constraints on dairying practices, a proactive approach to cow welfare is crucial. Such an approach should involve an evaluation of the potential welfare implications of the technical innovations identified as important for the sustainability of dairying in Ireland. These innovations include:

1. using genetic selection incorporating fitness and other traits relevant for cows in pasture-based systems of milk production;
2. maximising utilisation and performance from grazed grass;
3. developing low fixed-cost systems to allow dairy farmers to expand; and,
4. developing labour-efficient systems of production.

At Moorepark, during a five-year research programme on dairy cow welfare, several aspects of these innovations were assessed. Dairy cow welfare was evaluated using a diverse range of measurements, encompassing behaviour, health (including mastitis and lameness), fertility, stress physiology and immune function. The range of measurements used reflects the challenges associated with measuring animal welfare; single indicators are inadequate to measure such a complex issue.

Genetic selection

In the past, genetic selection within the Holstein-Friesian breed was exclusively on the basis of milk yield and this had detrimental implications for fertility, health and, ultimately, for cow survival. The Irish Economic Breeding Index (EBI) attempts to address this problem by including traits such as survival, fertility and



Walking on farm roadways is a major risk factor for lameness in cows in grass-based production systems.

health, as well as selection for higher milk solids, the latter being more relevant than milk yield in grass-based milk production systems. For this reason, selection for high EBI genetics should result in cows that are fertile, show a low incidence of disease and that ultimately have good welfare and longevity in our milk production systems.

Lameness

After mastitis, lameness is the second most important cause of poor longevity in dairy cows. It is also the major welfare problem of dairy cows because of the pain it causes. Previous research at Moorepark showed that the average number of animals that became lame per six-month period (January to June or July to December) on 14 commercial dairy farms was between 12 and 16 per 100 cows. However, on individual farms, the figure could be as high as 31 per 100 cows during any six-month period, which indicates the extent of the problem. We evaluated indicators of lameness in cows from three genetic strains; two were classified as high EBI but had either North American (NA) or New Zealand (NZ) ancestry, and the third was of low EBI with NA ancestry. We found that, irrespective of their ancestry, higher EBI cows had equal or improved locomotion ability, less severe hoof disorders and less clinical lameness than animals of lower genetic potential.

Fertility, health and immune function

We also investigated fertility, health and immune function in these animals during the peripartum and early lactation period. During this time, dairy cows are particularly susceptible to poor welfare caused by stress and disease – ultimately leading to reproductive problems. Our studies indicate that high EBI cows tend to have lower somatic cell scores and fewer mastitis problems at calving. However, while disease and fertility outcomes were similar for high EBI cows of either NA or NZ ancestry, they had different physiological strategies for coping with the stresses associated with calving. Considering that the ancestors of these cows were selected in different environments (i.e., NZ=pasture vs. NA=confinement) and, hence, with different breeding goals, these differences could reflect inherited peripartum adaptation strategies. A greater understanding of such differences will be required in order to avoid any deleterious effects arising from the use of high EBI genetics.



After mastitis, lameness is the second most important cause of poor longevity in dairy cows. It is also the major welfare problem of dairy cows because of the pain it causes.



Increasingly large herd sizes and fewer labour units mean that the periparturient cow could get less attention at a time when she is at her most vulnerable.

While the outlook for the EBI in terms of improving cow health is good, selection for high EBI could have an unforeseen impact on other correlated traits that influence cow welfare. For example, research conducted in the UK showed that dairy cows from sires that scored high for health, fertility and survival were more aggressive at feeding than cows from sires that scored low for these traits. In Ireland, to date, there has been no research on the effect of selective breeding on aspects of behaviour that influence cow welfare.

Maximising utilisation and performance from grazed grass

In Ireland, the cheapest and most efficient way of producing milk is from grazed grass. The welfare advantages associated with this system of milk production compared to confinement-based systems are significant. Initial results from a trial conducted at Moorepark indicate that the prevalence of lameness in cows at grass was 17%, compared to 42% indoors, while the prevalence of mastitis was 35% in cows at grass, compared to 65% indoors. Furthermore, cows at grass showed better locomotory ability, lay down for longer and, ultimately, had fewer reproductive disorders compared to cows kept indoors. These findings help to strengthen the potential advantage Irish dairy producers will have over their European counterparts if legislation implementing access to pasture is enforced in the future.

In light of future constraints on dairying practices, a proactive approach to cow welfare is crucial.

Nevertheless, new strategies to maximise the utilisation of, and performance from, grazed grass in the diet could have negative welfare implications for dairy cows. We found that the hoof health of dry cows out-wintered on deferred grass was poorer compared to cows that were housed during the winter. Furthermore, we noticed deterioration in the hoof health of lactating cows that were at grass late in the autumn. There are several possible explanations for these findings. Firstly, extended grazing (where lactating cows are turned out early in the spring and are at grass for longer in the autumn) and, secondly,

out-wintering dry cows on deferred grass means that animals are outside when the weather is poor in paddocks that are often unsheltered. This, combined with wet, muddy underfoot conditions, deters cows from lying down. Prolonged standing is not only a major stressor of dairy cows but also contributes to hoof problems. Furthermore, exposure to high levels of rainfall can cause the hooves to soften, which makes them more susceptible to injury, particularly if the cows have to walk on muddy roadways. Clearly, strategies to maximise the use of grazed grass need to be developed, in conjunction with research on shelter options for cows at pasture, and alternative materials for farm roadways to minimise lameness.

Developing low fixed-cost systems

One of the main low fixed-cost systems evaluated at Moorepark and other Teagasc centres during the past few years, was out-wintering pads (OWPs). OWPs allow most classes of beef and dairy cattle to be kept outdoors during the winter in a free draining area on a bed of woodchips. Given the costs associated with cubicle housing for dairy animals, they are a key feature in the expansion of a dairy herd. As previously mentioned, keeping dairy animals outdoors during periods of bad weather has implications for welfare. Our findings suggest, however, that (at least in the north Cork region) the risk of cold stress during the winter is minimal, although periods of wet and windy weather cause cows to spend less time lying down than they would in cubicles. Cows on OWPs also have softer hooves compared to animals indoors and this can have negative implications for hoof health once the cows recommence walking to and from the parlour for milking. However, we found little difference in the incidence of lameness during the winter period. In replacement dairy heifers, OWPs were also associated with behavioural indicators of good welfare, such as an increased incidence of play and comfort behaviours. OWP heifers also suffered fewer leg injuries than heifers indoors. These benefits were attributed to higher space allowances and more comfortable underfoot conditions compared to cubicle accommodation. Certainly, when management is good, the woodchips are cleaned regularly and shelter is provided, OWPs have the potential to improve the welfare of dairy animals over conventional systems. This is good news for producers wishing to increase their herd size without incurring high fixed costs.

T Livestock



In most EU countries cows are housed all year round, whereas in Ireland cows are at grass for between six and 10 months of the year.



One of the main low fixed-cost systems evaluated at Moorepark and other Teagasc centres during the past few years, was out-wintering pads (OWPs).

Developing labour-efficient systems of production

In Ireland, where herd sizes are increasing and there is a shortage of people willing to work on dairy farms, labour-efficient systems of production are crucial factors affecting expansion and sustainability. In the future, the EBI should help to ensure that dairy workers will not need to spend excessive amounts of time trying to get their cows in calf, in nursing them through illnesses or in treating lameness. This will contribute to improved labour efficiency on dairy farms. However, one area of concern is in the care of cows (and their calves) during the calving season. Grass-based milk production systems are characterised by a highly seasonal calving pattern, meaning that all the cows ideally calf within a few weeks of each other. However, unlike grass-based systems in New Zealand, where cows generally calve at grass with little or no supervision, calving in Ireland is highly managed, i.e., the cows calve indoors under supervision. This, combined with increasingly large herd sizes and fewer labour units, means that the periparturient cow is likely to get less attention at a time when she is at her most vulnerable. There is likely to be a minimum below which the number of labour hours per cow per year cannot be reduced without welfare implications.

Once-a-day milking

A labour-efficient system of milk production that was comprehensively evaluated at Moorepark was once-a-day (OAD) milking. OAD milking is of interest to a niche group of farmers, particularly those with off-farm employment. The dairy cow welfare team worked together with researchers investigating effects on milk production, quality and processability, to determine the welfare implications of this practice. We found that, towards the end of the grazing season, hoof health in cows milked once a day was superior to that of cows milked twice a day. We attributed this to the 50% reduction in walking to and from the parlour for milking. In early to peak lactation, however, OAD milking had some negative

implications, as the cows suffered from discomfort caused by udder distension. This was reflected in abnormal locomotion, disturbed lying patterns, milk leakage and a detrimental effect on the functionality of cells of the immune system. Indeed, the latter finding suggests that there may have been some psychological stress associated with the practice. Cows will voluntarily enter automatic milking systems up to three times per day, suggesting that they 'prefer' to be milked more frequently, particularly in the period up to peak lactation.

Future

We are in an era of increased public awareness about farm animal welfare. Therefore, public acceptance of the breeding, feeding and management practices employed in the dairy industry is crucial. This, combined with tighter restrictions on dairying through EU animal welfare legislation, means that there will be a substantially increased need for work on dairy cow welfare in general and, particularly, on dairy cow welfare in pasture-based systems of milk production.

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Present beef carcass prices do not reflect quality

The cattle pricing structure in Ireland must be reviewed if the emphasis in breeding goals is to be placed on improving carcass meat yield and distribution, in addition to meeting export market requirements, contend MICHAEL DRENNAN and STEPHEN CONROY, Grange Beef Research Centre.

Beef carcass prices should take account of meat yield and market value. A carcass dissection study was carried out with 336 steers representing the various sections of the carcass classification grid for conformation and fatness, and the value of each carcass was calculated based on the wholesale value of each meat cut. The results showed that on a scale of one to five, a one-unit increase in conformation (e.g., O to R) at constant fat score increased meat yield by 3.4 percentage units and carcass value by 18c/kg, which is double that paid by meat processors in Ireland in 2007. In the high priced continental EU markets, where requirements are for carcasses of good conformation that are lean, a one-unit increase in conformation score can increase value by up to 80c/kg. Therefore, it is in the interest of farmers, processors and all those associated with the beef industry, that the Irish carcass price is adjusted to better reflect carcass quality. For such a price structure change to take place, it is necessary that carcass conformation and fat scores use a 15-point scale rather than the present five-point scale. Using a 15-point scale, a one-unit increase in carcass conformation score should result in a price increase of at least 6c/kg (i.e., 18c/kg on the present five-point scale). This suggested difference is based on meat yield and distribution, and does not take into account factors such as the higher processing costs associated with poorer meat yield or the increased value of better quality carcasses in continental EU markets.

Introduction

During the last 23 years, suckler cow numbers in Ireland have increased almost three-fold – from 0.44 million in 1984 to 1.19 million in 2007. There has also been a substantial increase in the use of late-maturing continental breeds in the suckler herd. Late-maturing breeds and crosses now account for over 70% of suckler cows, of which 88% are bred to continental sire breeds. Such a breeding policy would lead to an increased proportion of animals suitable for the higher-priced continental EU market, where prices are highest for animals of good conformation that are lean. As 85% of Irish carcass beef is exported, of which 45% is destined for continental EU markets, it is important that the animals



Image courtesy of Bord Bia.

produced meet the requirements of those markets. An examination of steer and bull beef prices for 2007 shows that, when compared to Ireland, average beef prices in France and Italy were only 9c/kg greater for O3 carcasses but were 63c/kg greater for U3 carcasses. Thus, the price difference between beef prices in Ireland and the average for those two countries was seven times greater for Us than for Os, showing the extent to which carcasses of good conformation are under-priced in Ireland. Therefore, market outlet, in addition to carcass meat yield, is important in determining carcass value. The results of a comprehensive study with steers are presented here, the objective of which was to determine the effect of carcass conformation and fat scores on meat yield and value.

TABLE 1: The effect of a one-unit increase in conformation score in steers.

	O3	R3	Difference
Meat (%)	66.5	69.9	+3.4
Fat (%)	12.2	11.2	-1.0
Bone (%)	21.2	18.8	-2.4
High-value cuts (%)	6.9	7.2	+0.3
Value (c/kg carcass)	312	330	+18

Steer experiment

Materials and methods

A total of 336 steers were used, representing the various sections of the five-point scale carcass classification grid for conformation (E, U, R, O, P; with E best) and fatness (1, 2, 3, 4, 5; with 5 fattest). Carcasses were mechanically classified according to the EU Beef Carcass Classification Scheme. Carcass meat, fat and bone proportions were obtained by dissection of the right side of each carcass, which was quartered into an eight-rib pistola hindquarter and the remainder as forequarter. The pistola and forequarter were dissected into 12 and 11 meat cuts, respectively. Where applicable, the bones were removed from each cut and scraped clean. All dissectible fat was removed from each cut. The weight of each cut and total weight of fat trim, lean trim and bone were recorded for both the pistola and the forequarter. For both quarters, lean trim was added to the meat cuts to give meat yield. Total carcass yields of meat, fat and bone were the combined values for the pistola and forequarter. Carcass value was taken as the sum of the wholesale values of the individual meat cuts and meat trim in the half carcass, with a deduction for bone expressed as a proportion of the half carcass weight. Thus, when estimating carcass value, the weight of carcass fat was not considered.

Results

The slaughter and carcass weights of the steers were 640kg and 342kg, respectively. Regression analyses were used to quantify the relationship between carcass conformation and fat scores, with carcass meat, fat and bone proportions, meat distribution and carcass value (Tables 1 and 2). A one-unit increase in carcass conformation score (e.g., O3 to R3) increased meat yield by 3.4 percentage units and decreased fat and bone yield by 1.0 and 2.4 percentage units, respectively. A one-unit increase in conformation score also increased high-value cuts by 0.3 percentage units and increased carcass value by 18c/kg. The effect of a one-unit increase in carcass fat score was an increase of 3.3 percentage units in fat and decreases of 2.4 and 0.8 percentage units in meat and bone, respectively. There was also a reduction of 0.5 percentage units in high-value cuts. A one-unit increase in fat score decreased carcass value by 17c/kg. There is a minimum fat requirement, which varies with the actual market (greater in the UK than in continental EU), and thus, unlike conformation, changes in fat score do not apply across the entire carcass classification grid.

Suckler herd progeny vs. Holstein-Friesian steers

Included in the 336 steers were 94 progeny from the suckler herd (about $\frac{7}{8}$ late-maturing continental breeds) and 76 Holstein-Friesians. The carcass weights of

TABLE 2: Effect of a one-unit increase in fat score in steers.

	R3	R4	Difference
Meat (%)	69.9	67.5	-2.4
Fat (%)	11.2	14.5	+3.3
Bone (%)	18.8	18.0	-0.8
High-value cuts (%)	7.2	6.7	-0.5
Value (c/kg carcass)	330	313	-17

the sucklers and Holstein-Friesians were 404 and 316kg, respectively.

Corresponding conformation scores were U- and O-, while both had similar fat scores of 3+ (using the proposed 15-point scale). The sucklers had 6.2 (71.2 vs. 65) percentage units more meat, 1.7 (11.5 vs. 13.2) percentage units less fat, 4.5 (17.3 vs. 21.8) percentage units less bone, 0.5 (7.1 vs. 6.6) percentage units more high-value cuts, and were valued at 36c/kg carcass more than the Holstein-Friesians.

Comparison of meat yield and distribution results with market prices

The price (ex. VAT) advantage of U3 over O3 (a two-unit change) steer or bull carcasses in 2007 was 18, 23, 64, 80 and 45c/kg in Ireland, Great Britain, France, Italy and Spain, respectively. With the exception of Ireland and Great Britain, the advantage in EU countries was considerably greater than the 37c/kg calculated for steers in the present study, based on meat yield and distribution. It is noticeable that in continental EU markets, the effect of conformation score on heifer prices is even greater than for steers/bulls. It is evident that the cattle pricing structure in Ireland must be reviewed if the emphasis in breeding goals is to be placed on improving carcass meat yield and distribution, in addition to meeting export market requirements.

Beef carcass classification

Beef carcass classification data for 2007 shows that 87% of steers and 91% of heifers fall into the combined conformation classes of O and R (Table 3). Therefore, a better differentiation would be achieved by grading on a 15-point scale (e.g., R-, R, R+) rather than on a five-point scale. For the same reason, it would be more informative to have carcass fat class also graded on a 15-point scale. The mechanical carcass classification system currently in operation at Irish meat processing plants would immediately facilitate this expanded grading system.

TABLE 3: Percentage of beef carcasses in the different conformation classes in 2007.

	E	U	R	O	P	Carcass wt (kg)
Steers	-	7	45	41	7	358
Heifers	-	6	55	36	3	291

Source: Department of Agriculture, Fisheries and Food, 2007.



Mechanical classification of beef carcasses for conformation and fatness is now carried out at all Irish beef processing plants.

It is suggested that by using this expanded beef carcass classification system for conformation, a premium of 6c/kg on a 15-point scale (=18c/kg on a five-point scale) is merited based on meat yield alone, while a greater premium would be due if savings in processing overheads were also considered.

It is in the interest of farmers, processors and all those associated with the beef industry, that the Irish carcass price is adjusted to better reflect carcass quality.

In addition, the premium would be substantially higher if higher-priced market outlets were also considered. Similarly, a deduction of 6c/kg per unit increase in fatness on a 15-point scale for over-fatness (i.e., above that required by the specific market) is also justified based on the results of the present study.

Implications

Use of such a pricing system would lead to an overall improvement in the quality of carcasses produced and provide more animals suitable for the high-priced continental EU market. As the suckler herd is the source of the higher quality carcasses, the improved income from suckling would help to maintain suckler cow numbers and thus beef output. This is important, as the EU is only 94% self-sufficient in beef and almost 90% of Irish beef output goes to other EU markets.

Recommendations

- Carcass grading for conformation and fatness should be on a 15-point scale;
- a price premium per unit improvement in conformation of at least 6c/kg on a 15-point scale (=18c/kg on a five-point scale) is merited based on carcass meat yield and distribution; and,
- a deduction in carcass price per unit increase in fat score of 6c/kg on a 15-point scale for over-fatness.

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Future work will focus on using genetic selection and/or suitable maternal feeding regimes to produce litters with reduced intra-litter variation in birth weight.

Prenatal events affect postnatal muscle growth and meat quality

PEADAR LAWLOR and BRENDAN LYNCH of the Teagasc, Pig Production Development Unit, Moorepark, report on the results of an EU project that looked at how muscle growth and meat quality of pigs is affected by prenatal events.

COST – European Co-operation in the field of Scientific and Technical Research – is one of the longest-running European instruments supporting co-operation among scientists and researchers across Europe. The focus of COST Action 925 was on: "The importance of prenatal events for postnatal muscle growth in relation to the quality of muscle-based foods", and covered a range of meats and fish. The main objective of this project was to explain the interactions between genetics and environment in prenatal events of muscle formation. This information is necessary to identify new and alternative methods to be used for selection and animal feeding to optimise postnatal growth and meat quality.

Genetic selection for muscle structure and meat quality

Structural and functional properties of muscle fibres are correlated with meat quality traits in pigs. Muscle fibre traits, like growth traits, have moderate to high heritability ($h^2=0.20-0.59$) and are generally higher than those for meat quality traits ($h^2=0.15-0.32$). In recent times, there has been intensive selection for increased lean growth in pigs. This has impacted negatively on meat quality as a consequence of increased susceptibility to stress, which is associated with fibre hypertrophy, appearance of giant fibres and an increase in the incidence of pale, soft exudative meat.

Simulated selection using a large pig data set has revealed that selection responses in growth, carcass and meat quality traits could be markedly improved if muscle structure traits were included in selection indices. This highlights why genes affecting foetal growth and muscle development impact on postnatal growth, as well as carcass and meat quality traits. In commercial pig breeding, selection for favourable muscle structure traits will simultaneously improve carcass and meat quality. Identification of candidate genes related to muscularity and meat quality may include those determining prenatal muscle development and regulation of anabolic (muscle growth) and catabolic (muscle breakdown) processes.



Taking muscle samples for fibre typing work.

Intra-litter variation and low birth weight in pigs

Birth weight and within-litter variation in birth weight are important economic traits in pig production. Genetic selection for large litters during the last decades has increased within-litter variation in piglet birth weight, and mean birth weight is consequently now lighter, due to intrauterine growth retardation. Low birth weight is correlated with reduced survival and lower postnatal growth rates, and there are indications that lower carcass weight and meat quality at slaughter result from such pigs.

The impact of genetic selection on prenatal events and how they influence postnatal growth performance remains to be elucidated. Pigs of low birth weight form a lower number of muscle fibres (**Figure 1**) during prenatal development and skeletal muscle appears to be less mature. Low birth weight pigs have lower growth rates and have lower lean meat yield, and are fatter at slaughter compared to high birth weight and medium birth weight pigs. This highlights the importance of intrauterine programming on muscle structure and growth, and also the development of obesity in adults. These effects seem to be more

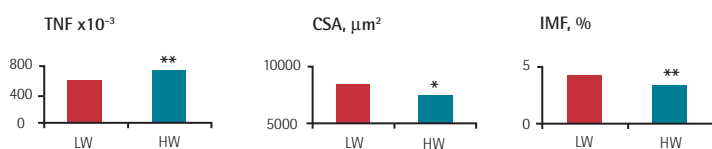


FIGURE 1: Influence of low (LW) vs. high (HW) birth weight on total number of fibre (TNF), myofibre (muscle fibre) cross-sectional area (CSA) and intra-muscular fat content (IMF) in pig semitendinosus muscle at market weight (Gondret et al., 2006).

pronounced in females than in males. Low birth weight pigs have larger muscle fibres than high birth weight and medium birth weight pigs and this is associated with poorer meat quality. Pork quality appears to be optimal in medium birth weight pigs but declines in low birth weight and high birth weight pigs. Recent studies show that using a compensatory growth strategy does not overcome the negative impact of low birth weight on growth and carcass characteristics (Gondret *et al.*, 2006).

Reducing intra-litter variation in birth weight (and muscle fibre number) will result in increased litter growth, more uniform carcasses and more consistent meat quality. Future work will focus on using genetic selection and/or suitable maternal feeding regimes to produce litters with reduced intra-litter variation in birth weight.

Do prenatal conditions determine postnatal performance?

Within litters, the variation in postnatal pig performance is large and this is partly due to variation in birth weight and the number of muscle fibres formed during embryonic/foetal life. Differences in muscle fibre number and birth weight are believed to be primarily due to malnutrition of the smaller littermates during foetal development. These differences affect the quality of the carcass and the meat at slaughter. To test the hypothesis that maternal nutrition affects the development of muscle in porcine foetuses, the effects of increased feed allowance during critical 'time windows' of gestation, when muscle fibres are formed, were investigated and related to growth and carcass quality. Increasing gestational feeding allowance had little effect on pig performance to slaughter but did reduce carcass fatness. Pig weight, daily gain and feed conversion efficiency recorded up to slaughter age remained unaffected (Nissen

et al., 2003; Lawlor *et al.*, 2007). Carcass back-fat thickness in progeny was reduced when maternal feed allowance was doubled between day 25 to 50, or day 50 to 80, of gestation (Lawlor *et al.*, 2007). Previous results have indicated that increased nutrient intake in critical time periods does not increase the number of muscle fibres in the progeny. Preliminary observations suggest that there are significant effects on fibre type profiles at slaughter.

Maternal 'overnutrition' is not very effective in stimulating myogenesis (the formation of muscle fibres) and increasing the birth weight of progeny. There are some indications that changes in maternal nutrition during critical time windows may influence later carcass quality, and possibly a number of parameters in muscle, which have a known relationship with several meat quality traits.

Genetic markers to measure and predict carcass and meat quality

Growth performance, carcass and meat quality, and health are of economic importance in animal production. The development of measurable biological indicators (biomarkers) for these important trait complexes is required for knowledge-based optimisation of high-quality meat production with healthy animals and quality-based product differentiation.

Biomarkers are developed using 'omics' technologies that deliver profiles with respect to genome variation, gene expression, and protein (metabolite) composition. Biomarkers detect carcass and meat quality at slaughter, or predict the predisposition for performance traits during life and early after slaughtering. So far, markers for pork quality (quantitative trait loci – QTLs) have been detected and the candidate genes are being studied: candidate genes for congenital splay leg in pigs are being identified; and, mutations in the IGF-II and MC4R genes have been associated with lean meat content and growth rate in pigs. In the future, biomarkers will assist the pig industry to genetically improve the potential for high carcass quality, meat quality and animal health. It is also envisaged that markers will also be used in the future to differentiate meat quality in the slaughterhouse and meet consumer preference.

The impact of bioactive compounds on muscle growth

The control of skeletal muscle cell growth and differentiation is multi-factorial, involving hormones, growth factors and nutrients. Myogenic cell cultures (cells from which muscular tissue is formed) are valuable tools to investigate the significance of these factors in growth regulation by monitoring their direct effects and interactions on physiological cell functions. Recently, cultures of pig muscle satellite cells (mononuclear progenitor cells found in mature muscle between the basal lamina and sarcolemma; satellite cells are able to differentiate and fuse to augment existing muscle fibres and to form new fibres) have been developed to study the direct effects of growth factors, oestrogens, and isoflavones on their growth. Isoflavones are plant-derived, steroid-like compounds that reach high concentrations in soy, a widely used food supplement in human and pig nutrition.

Insulin-like growth factor I (IGF-I) and, to a greater extent, epidermal growth factor (EGF), stimulate porcine muscle cell proliferation. Oestrogens have no effect, indicating that proliferation of porcine muscle cells is not stimulated via the oestrogenic pathway. High concentrations of the common isoflavones genistein and daidzein have a detrimental effect on cell proliferation and survival. In contrast, physiological concentrations of oestrogens and low concentrations of isoflavones have the potential to enhance net protein accretion in differentiated porcine skeletal muscle by inhibiting protein degradation.

Main findings

- Morphological and muscle structure traits and genes, which are important for carcass and meat quality, can be identified in pigs. Production strategies (e.g., selection) can use this information to improve quantity and quality of products;
- reduction in intra-litter variation in pig birth weight results in more uniform carcasses and meat quality. Genetic selection and/or suitable maternal feeding regimes should be applied to produce balanced litters with piglets of medium birth weights to high birth weights;
- maternal feed allowance above standard requirements in pigs appears not to be very effective in stimulating muscle development and increasing birth weight of progeny;
- biomarkers will assist animal breeders to genetically improve the potential for high carcass quality, meat quality and animal health; and,
- cell culture studies reveal significant influences of dietary isoflavones, peptide growth factors and cell type interactions on skeletal muscle cell growth.

In vitro assays provide a rapid means to screen for the potential effect of chemicals and biomolecules on myogenic cells. The studies indicate that excessive concentrations of dietary isoflavones may have a detrimental effect on skeletal muscle cell proliferation and survival. Environmental and genetic factors that modify the IGF-1 and EGF signalling pathway, or interactions between different cell types, may be of significance for skeletal muscle growth.

COST is supported by the EU Research and Technological Development Framework Programme. Further details on COST 925 can be found at www.agrsci.dk/costaction925/index.html.

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Breed composition of the national sheep flock



J.P. HANRAHAN reports on the most recent survey of the genetic make-up of the Irish national sheep flock and identifies areas of concern.

TABLE 1: Some key features of the hill and lowland sectors of Irish sheep production.

Sector	Main ewe breed	No. of ewes to the ram [§]	Main ewe breed	Lambs reared per ewe to the ram		Lamb carcass weight (kg)
				Total [§]	Surplus ⁺	
Hill						
- Western seaboard	Scottish Blackface	188	Scottish Blackface	0.83	0.55	14
- East coast	Cheviot	163	Cheviot	0.95	0.70	20
Lowland	Crossbred	114	Crossbred	1.25	1.05	20.5

[§] Based on National Farm Survey data 2005-2006.

⁺ After allowing for ewe lambs retained as replacements.

The primary purpose for keeping a sheep enterprise is to produce lamb meat for market. The number of ewes in the national flock that are put to the ram in autumn is obviously the key driver of the volume of lamb carcass production. However, because there are major sectoral differences in lamb carcass output per ewe, changes in the relative size of the main sectors will also impact on the volume of production. The Irish sheep industry can be divided into three sectors:

- hill systems based on Scottish Blackface ewes (western seaboard);
- hill systems based on Cheviot ewes (east coast); and,
- lowland systems.

The main characteristics of these sectors are indicated in **Table 1**. In the case of the Scottish Blackface hill system, the carcass weight estimate is based on the assumption that purebred lambs are sold for the light export market, while crossbred lambs are sold at weights suitable for the French market.

The Sheep Industry Development Strategy report, published in 2006, placed significant emphasis on the reorganisation of genetic improvement programmes, along with an agreed system for the description of product quality. The process of implementing the recommendations will need to take account of the breed composition of the national flock and its various components.

While the number of Scottish Blackface ewes was reduced by the de-stocking measures implemented in the late '90s and early part of the present decade, in the context of the Department of Agriculture, Fisheries and Food's Commonage Framework Plans, there are no recent data on the impact of this on the composition of the national flock. The impact of a change in the number of

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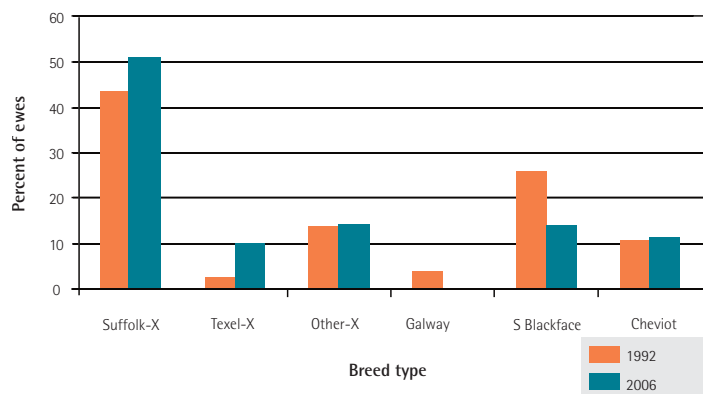


FIGURE 1: Breed composition of the national ewe flock.

Scottish Blackface ewes on the volume of lamb carcass output will be considerably less than any equivalent reduction in the size of the ewe population on lowland farms because of the low ewe productivity and low carcass weight associated with this sector.

As there has been no recent assessment of the breed composition of the Irish sheep population, a survey was undertaken during the autumn of 2005 using farms in the National Farm Survey. The survey was designed to get information on the breed composition of the ewe flock for the 2006 production season and to examine breeds and sources of stock rams used. Information was also obtained on the breed type of ewe lambs being retained for breeding purposes, and thus expected to be in the flock for the 2007 production year.

The principal results from this survey are summarised in this report, and changes in breed composition of the ewe population since 1992 (the last time this information was collected) are indicated.

Ewe breeds

The breed type of the ewes put to the ram for the 2006 production year was based on the breed of the sire of these ewes. The results are shown in Figure 1, along with corresponding values from the 1992 survey, which was undertaken by the Department of Agriculture, Fisheries and Food. The most outstanding change,

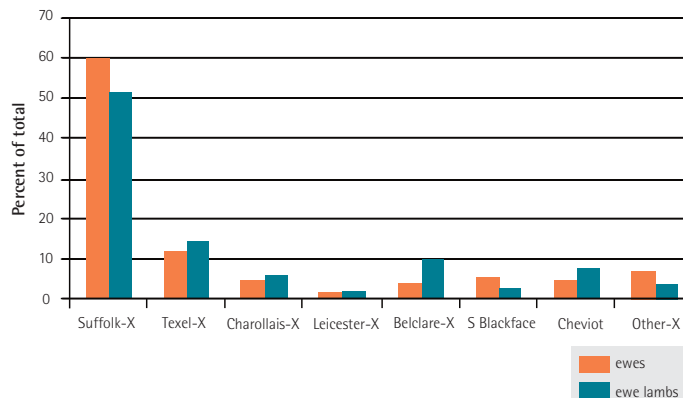


FIGURE 2: Breed composition of ewes and ewe lamb replacements on lowland farms.

as expected, was the decline in the percentage of Scottish Blackface ewes. The proportion of the ewes that were either Suffolk-X or Texel-X increased from a combined total of 46% in 1992 to over 60% for the 2006 production year, with the predominance of the Suffolk-X being maintained. There was no material change in the proportion of Cheviot ewes between 1992 and 2006.

The dominance of Suffolk-X ewes on lowland farms is illustrated in Figure 2, which gives further details on ewe breed types on these farms along with data on the breed of ewe lamb replacements. This provides some insight into any current changes in the breeding policy for flock replacements.

A disappointing feature of these results is the low proportion of rams that were purchased at pedigree sales

Based on the information shown in Figure 2, the proportion of Suffolk-X ewes in lowland flocks is around 60%, but declined to just over 50% in the case of ewe lamb replacements. The change in the Suffolk contribution is accounted for by noticeable increases in Belclare-X and Texel-X animals. The increase in the

Ram breed	Percentage of rams by breed ¹	
	Hill flocks	Lowland flocks
Suffolk	36	54
Texel	10	18
Charollais	5	14
Belclare	2	4
Vendean	0	4
Scottish Blackface	34	1
Cheviot	11	1
Leicester breeds	1	0

¹ A range of minor breeds are not listed.

Age at joining (years)	Lowland farms	Hill farms
<1	6.9	3.2
1.5	19.4	15.1
2.5	25.3	21.8
3.5	22.9	30.2
≥4.5	25.5	29.6

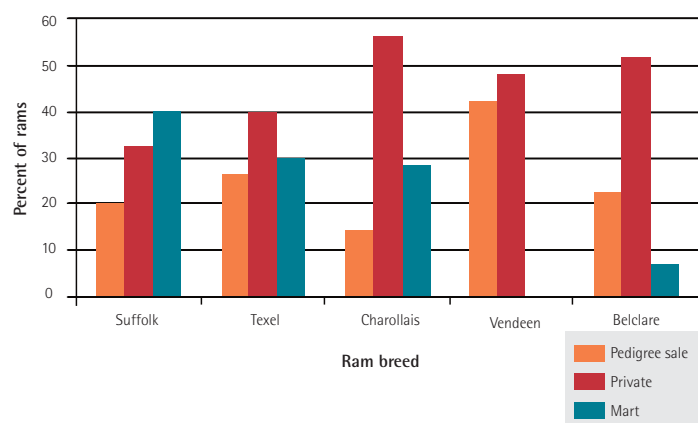


FIGURE 3: Percent of rams purchased at pedigree sales, at mart sales, and privately.

incidence of Belclare-X sheep among the replacements presumably reflects an increasing awareness of the need for increased productivity (more lambs reared per ewe to the ram), which is the characteristic of Belclare-X ewes.

However, in this context it should be noted that the total number of ewe lambs for breeding was only about 50% of the number expected, based on a typical annual ewe replacement rate. This means that a large proportion of flock replacements are purchased at 18 months of age and are unlikely to have been bred with ewe performance as the primary objective.

Ram breeds

The breed profile of stock rams is shown in **Table 2**; only breeds that accounted for at least 1% of the total are included here. In lowland flocks, more than 85% of the stock rams are from the main terminal sire breeds (Suffolk, Texel, Charollais) with the Suffolk predominating. This underlines the continuing absence of a specific policy on the production of prolific flock replacements, although the trends in Figure 2, as already mentioned, suggest a significant movement in this direction.

Information on the age profile of rams is contained in **Table 3**. Rams were older on hill than on lowland farms. The proportion of rams that were under

one year at joining is surprisingly low, especially in lowland flocks. The evidence suggests that rams are kept much longer than would be desirable if a key objective was to ensure that the genetic lag relative to ram breeding flocks was kept as short as possible. The ewe:ram ratios observed were 32 and 38 for lowland and hill, respectively. These are much lower than required biologically, but they can be explained to some extent by the small flock size and the risks that flock owners attach to reliance on a single ram where this would be biologically adequate. A consequence of the low ratios is that selection intensity for rams is much lower than it could be; this reduces the potential genetic gain by the sector, and this is compounded by the generally old age of the rams in use.

Another issue of relevance to policies for development of genetic improvement programmes is where farmers source their stock rams. The source of stock rams is given in **Figure 3** for the five most numerous breeds used on lowland flocks. Pedigree breed sales were not the dominant source of rams for any breed. The primary outlet for rams was private sales (i.e., sales at home), except for the Suffolk, for which mart sales predominated.

A disappointing feature of these results is the low proportion of rams that were purchased at pedigree sales, where information on breeding value for lean meat index (LMI) is available from breeders who participate in the Pedigree Sheep Breed Improvement Programme (PSBIP) for terminal sire breeds operated by the Department of Agriculture, Fisheries and Food. Across the three principal terminal sire breeds, fewer than 20% of rams are sourced from such sales. Since only about 25% of pedigree rams at pedigree sales of the terminal sire breeds are from PSBIP flocks, it is reasonable to conclude that the proportion of rams that are chosen by commercial breeders because of a high breeding value for lean growth is less than 5% of the stock of terminal sires on lowland farms. In the case of Scottish Blackface and Cheviot rams, only 14% and 8%, respectively, were purchased at pedigree breed sales, while 50% were purchased at marts. This is not surprising, given the low emphasis in these populations on pedigree details and on objective genetic improvement. On farms where the predominant ewe breed was Scottish Blackface, 70% of the rams were also of this breed. On this basis, the number of purebred females produced is reasonably close to the number required as flock replacements to maintain a stable flock size. This is not the case, however, in Cheviot flocks, where only

TABLE 4: Estimated number of ewes in the current national flock (by breed type).

Breed type	Number of ewes ('000)
Suffolk-X	1,348
Texel-X	258
Charollais-X	105
Leicester-X	41
Belclare-X	86
Scottish Blackface	368
Cheviot	309
Other-X	148
Total	2,663

TABLE 5: Estimated⁺ output of lamb carcass by ewe breed type.

Ewe breed type	Volume of lamb carcass output ('000t)	Percent of total
Scottish Blackface	2,800	5%
Cheviot	4,500	9%
Lowland flocks	43,600	86%
Total	50,900	

⁺ These estimates are based on the number of ewes in the national flock in December 2007 and the productivity values shown in Table 1.

17% of the rams were purebred Cheviots and the majority (57%) were Suffolk. As a consequence, the potential production of purebred Cheviots would only provide about half of the required replacement rate. If this pattern continues, there will be a significant decline in the percentage of Cheviot ewes in the national flock over the next number of years.

Contribution of the sectors' lamb carcass output

The estimate for the total number of breeding ewes in December 2007 was 2.66 million (Central Statistics Office). Thus, we can estimate the number of ewes by breed type and the results are shown in **Table 4**. These numbers were used to estimate the contribution of the three main sectors to the volume of lamb carcass output using the productivity values and carcass weight data in **Table 1**. The results are in **Table 5** and show that something in the order of 86% of total lamb carcass output comes from lowland flocks, about 9% comes from Cheviot flocks and at most around 5% emanates from the Scottish Blackface ewe population in the country. Not all of the Scottish Blackfaces are on hill farms, so it seems safe to conclude that the Scottish Blackface hill flock, i.e., Scottish Blackface ewes on hill farms, accounts for less than 5% of the lamb meat output from the national sheep flock.

Obviously, the proportional contribution of the sectors to total lamb output will have to be taken into account in developing the new genetic improvement programme for the sheep sector, in the implementation of the recommendations in the Sheep Industry Development Strategy.

Key points

- The lowland sheep sector continues to be dominated by terminal sire breeds – especially the Suffolk;
- there is evidence of some current increase in the proportion of prolific replacements in lowland flocks at the expense of Suffolk-X types;
- as only a very small proportion of stock rams are sourced through pedigree breed sales, there is little opportunity for engagement between the breeders involved in the PSBIP and commercial sheep producers;
- the age profile of rams and ewe:ram ratios are not at levels that would be desirable to maximise the potential gain from genetic improvement programmes;
- given the pattern of ram usage on hill flocks, the Scottish Blackface sector is barely producing enough purebreds to maintain the current population, but the current usage of Cheviot rams cannot sustain the purebred Cheviot population; and,
- the Scottish Blackface ewe population accounts for no more than 5% of the total output of lamb meat. This has implications for the investment of effort in genetic improvement programmes into the future.



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High energy costs impact on the production costs of most goods. Agriculture is no exception, with oil/energy prices affecting many of the factors of production. Today's tillage crop production systems are quite energy intensive. Can this energy input be reduced? Research at Oak Park Crops Research Centre is indicating that fuel/energy inputs can be reduced, but this requires considerable change in practices, which cannot be undertaken lightly, explains DERMOT FORRISTAL.

Minimum tillage to

Ireland's tillage crop growers produce some of the highest crop yields in the world, with winter wheat and spring barley averaging almost 10t/ha and 7t/ha, respectively. The production systems used, however, could be described as 'high-input', where all inputs, including fertiliser, plant protection agrochemicals and machinery inputs, are optimised to allow the high yielding capacity of our soils and climate to be exploited. This approach involves a considerable energy input and, consequently, must be challenged in today's energy scenario. While oil prices will always fluctuate, supply and demand factors will result in a trend towards higher energy costs.

In crop production systems, high fuel costs directly affect machinery operating costs and crop drying and transport costs. Oil prices also impact on fertiliser costs (particularly nitrogen [N]) and plant protection products and, to a lesser extent, on all purchased inputs. Research at Oak Park Crops Research Centre indicates that there is scope to reduce both the direct and indirect fuel-related costs in tillage crop production. This article focuses primarily on the direct fuel costs incurred by the use of machinery in crop production.

Indirect fuel costs

If tillage farmers could reduce their inputs of fertiliser and agrochemicals, such as fungicides and herbicides, the use of energy in crop production would decrease, and the impact of oil prices on crop production costs would be reduced. A long-running cereal systems trial at Oak Park, which compares 'low' and 'high' input strategies, indicates that energy input savings can be made in certain situations. With winter wheat production, a reduction of 20% in the N fertiliser rate and 50% in the herbicide and fungicide rates only reduces crop yields by about 8%. Even in times of low oil prices (< \$50/barrel), this low input strategy is more profitable for winter wheat producers, in addition to being more energy efficient. However, the response is crop specific. When a similar low input strategy is applied to spring barley, the average 18% reduction in yield results in lower



reduce fuel use in crop production

profits despite the indirect energy saving. While input levels can impact on energy use, the low input strategy must be approached carefully to avoid profit penalties.

Direct fuel use in machinery

The machinery used in the field to establish, tend and harvest crops uses significant levels of fuel. While there are many sources of fuel use data, few relate to Irish crop production conditions. A detailed Teagasc machinery cost survey indicated that cereal production required approximately 85 litres of fuel per hectare (or 7.5 gallons/acre), but this varied considerably from farm to farm. At today's prices, fuel costs about €68 per hectare and now accounts for about 20% of total machinery costs, compared to just 8% less than a decade ago. However, this research does not allow factors influencing fuel use to be determined. To indicate the scope for fuel savings, it is useful to examine the fuel consumption of individual operations. Fuel use rates for individual machine operations are given in **Table 1**. This highlights the high rates of fuel consumed during cultivation.

Many factors influence the level of fuel consumption on tillage farms. Some, like soil type and weather conditions, are outside of the grower's control. Others, like machine system choice, can be determined by the grower.

Choice and use of machinery

One option for fuel saving is to choose machines with efficient engines and operate them efficiently in the field. While savings made with these approaches can be significant, they are relatively small. To achieve large fuel savings, the entire machine systems used must be considered. In crop production, there is significant scope for energy reduction in the cultivation practices that are used to establish the crop. Minimum tillage (min till), where shallow non-inversion cultivation is used in place of deeper plough-based systems, offers scope for considerable energy and fuel savings.

Min till to save fuel

Min till systems offer scope for fuel saving. The source of this potential is primarily the shallower cultivation depth compared to ploughing (typically 75mm compared to 200+mm) and, occasionally, some reduction in the intensity of cultivation. While the energy requirement and fuel use of cultivation systems was researched in the past in other countries, there has been little research into the power/fuel requirement of the systems that have currently evolved under Irish conditions.

As part of the Oak Park research programme on min till, an intensive survey of machine work rates (i.e., time taken to complete work) on a number of tillage farms was undertaken. While fuel consumption was not directly measured in this study, estimates could be made using tractor engine power output, engine loading factors and specific fuel consumption values. This allowed the fuel use per hectare for different machinery operations to be calculated (**Table 2**).

TABLE 1: Typical fuel requirements for field operations.

Operation	Fuel consumption (litres/hectare)
Subsoiling	15
Ploughing	21
Heavy cultivation	13
Light cultivation	8
Rotary cultivation	13
Fertiliser distribution	3
Grain drilling	4
Rolling	4
Spraying	1
Combine harvesting	11

Min till



The minimum tillage (min till) system is a shallow cultivation system where the soil is not inverted and is worked to a depth of just 50mm to 100mm during cultivation and sowing operations. Traditional plough-based systems cultivate to a depth of 200mm to 250mm and invert the soil to achieve a level of weed control. Variations of the min till system have been tried since the 1960s, with little commercial interest in this country until recently. Today, developments in drilling technology and weed control strategies give the system a better chance of success. The system has potential cost and labour advantages, and may also have a positive impact on soil fauna such as earthworms, and soil structure protection. Grass weed control, suitability for wet autumns, and uncertainty about its role with crops established in the spring, are among the system's drawbacks. Research at Oak Park has focused on the impact of min till on winter wheat and, more recently, spring barley performance, with particular emphasis on yield stability, soil fauna, power requirements and the time taken to prepare the soil, i.e. work-rate (ha/h). To date, the performance with winter wheat has been acceptable, with good yield stability, but grass weeds can be problematic.

TABLE 2: Estimated power input and fuel consumption of different tillage operations.

Operation	Power available (kWh/ha)	Power used (prop)	Energy input (kWh/ha)	Specific fuel consumption (kg/kWh)	Fuel use (kg/ha)	Fuel use (litre/ha)
Plough	82	0.80	59.04	0.30	17.71	21.61
One pass	44.7	0.85	34.20	0.33	11.11	13.56
Roll	15.6	0.50	7.02	0.35	2.46	3.00
Min. tillage cultivator	21.3	0.85	16.29	0.30	4.89	5.96
Min. tillage drill	29.9	0.70	18.84	0.30	5.65	6.89

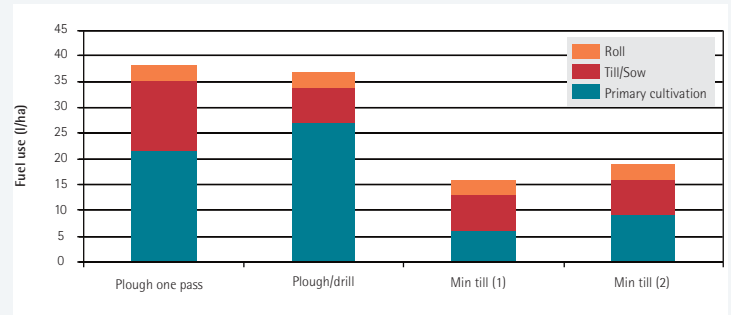


FIGURE 1: Estimated fuel consumption rates for different crop establishment systems.

The calculated fuel consumption figures correlate reasonably well with those from earlier UK research where comparable operations are available.

Cultivation system fuel requirements

The estimated fuel consumption figures can be compiled to allow us to compare the fuel efficiency of commonly used plough-based and min till establishment systems, each of which use a number of operations. Four such systems are compared in Figure 1. A plough system that uses a power harrow and mounted drill (one pass system) has a similar fuel use rate to that using a furrow press and a cultivator drill (plough/drill system). These are currently the two most commonly used establishment systems in Ireland. The min till systems have a much lower fuel demand at approximately 50% of that of the plough-based system, depending on whether one (min till 1) or two passes (min till 2) of the stubble cultivator are needed. Growers using min till generally use just one stubble cultivator pass.

These fuel use differences are substantial (Figure 1). Using a fuel cost figure of €0.80/litre, min till systems save about €18/ha in fuel costs alone. The difference in total machinery cost between the two systems is much greater, as the lower energy consumption of the min till system requires a reduced power input, which results in a similar reduction in machine capital (depreciation and interest) costs and wear/repair rates. The lower fuel use of the min till systems also contributes to a direct reduction in greenhouse gas output.

Min till adoption

A relatively small number of growers, farming large areas, have adopted min till crop establishment systems to date. To have a significant impact on our national fuel/energy use, the rate of adoption must be increased. The changeover requires serious consideration by growers as it involves machinery investment and higher levels of management. Risk is also increased due to the unknown long-term effects of adopting the system and limited research on its performance with spring barley. Our current research programme is targeted at these areas with the aim of underpinning future uptake of min till.

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The trailing shoe, bandspreader and splashplate slurry application systems were demonstrated at the Teagasc 'Slurry and Nutrient Efficiency Display' held at Johnstown Castle on May 1, 2008.

Slurry application using trailing shoe – potential benefits come at a price

As chemical fertiliser prices increase, the role of slurry as a nutrient source has come under the spotlight. STAN LALOR and ROGIER SCHULTE report on research in Johnstown Castle investigating the potential to increase the nitrogen fertiliser replacement values of slurry through application timing, and application method.

The management of cattle slurry application to grassland has received much attention in recent years. Up to now, slurry has been the focus of many debates regarding the environmental and regulatory consequences of its management, culminating in the creation of the Nitrates Directive legislation introduced in 2006. The requirement to assume standardised nitrogen fertiliser replacement values (NFRV) of up to 40% for cattle slurry is implicit in these regulations. However, due to the dramatic increase in chemical fertiliser prices that have occurred in 2008, the regulatory aspects of slurry application have been overshadowed. As fertiliser price increases, so too does the relative value of slurry as a nutrient source, as greater monetary savings through reduced fertiliser usage can be realised by improving slurry management. Research in Johnstown Castle has been investigating the potential to increase the NFRV of slurry through application timing, and application method.

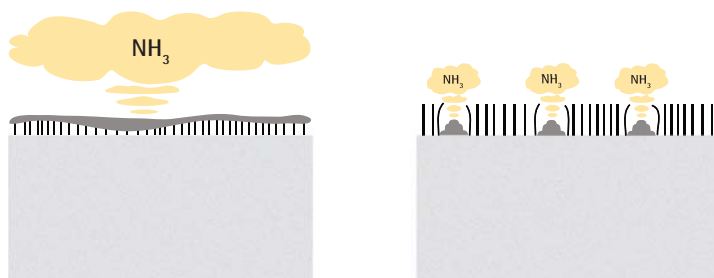


FIGURE 1: The low emission application methods (trailing shoe), shown on right, reduce the surface area of slurry exposed for loss of ammonia (NH_3) to the air compared with splashplate application (shown on left). Grass contamination is also reduced with trailing shoe application.

TABLE 1: NFRV and value (€) per m^3 of cattle slurry applied with splashplate and trailing shoe at different application timings based on experiments to date (based on typical total N content of 3.6kg N/m^3 slurry).

	Kg N/m^3 slurry		Value N/m^3 slurry	
	Splashplate	Trailing shoe	Splashplate	Trailing shoe
April	1.05	1.40	€1.26	€1.68
June	0.36	0.75	€0.43	€0.90

Alternative application methods – trailing shoe

Low emission slurry application methods have been adopted in some European countries to reduce the losses of N (ammonia) to the air following landspreading. Ammonia loss to the air from slurry has two consequences: 1) N contained in slurry as ammonia that is lost to the air is no longer available for plant uptake, reducing the NFRV of the slurry application; and, 2) ammonia emissions to the air have environmental implications for acid rain and N enrichment of sensitive habitats.

Loss of ammonia from slurry to the air occurs as slurry dries out after application. This process is called volatilisation, and is driven by the weather conditions at the time of application. High solar radiation intensity (sunshine), warm air and soil temperatures, high wind speed, and low relative humidity in the 24- to 48-hour period after application are all critical in determining the ammonia loss, and hence the NFRV, from the slurry application. Applications should be targeted towards weather conditions that are dull, cool and calm in order to minimise losses of ammonia to the air.

A number of low emission application methods are available, such as shallow injection, trailing shoe, and band spreading. The shallow injection method shows best results for reducing ammonia losses, as the slurry is injected into the soil. However, considering the variability in texture, topography, stone content and moisture regimes observed in Irish soils, the trailing shoe and band spreading methods, which do not have to penetrate the soil surface, are usually more suited to Irish conditions.

Low emission application methods work on the principle of reducing the surface area of slurry that is exposed to the prevailing weather conditions. Rather than applying a thin film of slurry over the entire spreading width of the machine as per the splashplate, the low emission methods apply slurry in a series of narrow bands (Figure 1). Concentrating the slurry into bands reduces the surface area of slurry exposed for ammonia loss, and also dramatically reduces the proportion of the grass canopy that is contaminated with slurry.

Results

Experiments began in 2006, and will continue into 2009, to examine the effect of application timing (spring vs. summer) and method (splashplate vs. trailing shoe) on the NFRV of cattle slurry on grassland. The dry matter yield of first-cut and second-cut silage crops are used to compare the efficiency of slurry N compared to fertiliser N applications. The experiment is being replicated at three sites of varying soil drainage regimes (well drained, moderately drained and poorly drained).

Initial results of these experiments show that, despite the trailing shoe showing significant reductions in ammonia losses compared to splashplate in many scientific investigations across Europe to date, the increase in the NFRV of slurry with the trailing shoe is relatively small. The trailing shoe increased the NFRV by approximately ten percentage points in both spring and summer. This corresponds to an increased NFRV of approximately 0.37kg N/m^3 of slurry applied. This increase in NFRV was similar in spring and summer application timings. At current fertiliser prices of approximately $\text{€}1.20/\text{kg N}$, the trailing shoe would increase the monetary value of slurry by approximately $\text{€}0.44/\text{m}^3$ (Table 1).

A larger increase in slurry NFRV was observed between the comparison of spring and summer application. Switching slurry application method from summer (June) to spring (April), within either application method, increased the NFRV by 18-19 percentage points. This corresponds to an increased N fertiliser of approximately 0.67kg N/m^3 of slurry applied. This increase in NFRV was similar with spring and summer application timings. Therefore, spring application would increase the monetary value of slurry by approximately $\text{€}0.80/\text{m}^3$ (Table 1). The increased NFRV observed with spring application was expected, as the weather conditions that cause high ammonia losses (sunshine and warm temperatures) are generally more prevalent in the summer period.

Towards spring application

Based on these findings, the priority for slurry application management should be to apply slurry in spring rather than summer. While spring application is generally advised, the weather conditions at the time of application are the key consideration, and applications should be targeted towards days or periods of minimal sunshine and cool temperatures.

Attempting to capitalise on spring application and weather-dependent opportunities for application requires considerable flexibility. The two main restrictions to slurry application are soil trafficability conditions and the grass cover on the areas designated to receive slurry. Application in summer is normally easily facilitated due to soil conditions that are normally dry at this time, and the absence of new grass growth in fresh silage stubbles. With splashplate, earlier applications that are targeted towards optimising the weather conditions on the day of application are more difficult, as such opportunities often arise on occasions when there is little or no spreadland area available with

grass covers that are low enough to ensure that grass contamination will not limit the subsequent grazing palatability or silage quality of the pasture. The trailing shoe offers advantages in this regard, as the slurry is concentrated in bands, with the result that the majority of the grass in the sward does not come into contact with the slurry. By reducing the grass contamination, the opportunity for more flexible application timing is increased as the consideration for grass cover is reduced. This means that on days when weather conditions that are ideal for slurry application arise (soil trafficability and reduced ammonia loss), more spreadland is available to the farmer with the trailing shoe compared to splashplate, as he/she is no longer restricted to areas with grass covers that are low enough so as not to affect subsequent grazing or silage quality.

The trailing shoe is not the only option to improve the opportunity for spring application. The umbilical application system, which pumps the slurry directly through a pipe system to a low-weight slurry application unit in the field, can be used to reduce soil compaction, as heavy tankers are avoided. Umbilical systems are now available with either splashplate or trailing shoe attachments. Also, with tanker application, tyre selection is an important consideration to aid soil trafficability and reduce the potential for damage that can result from machinery traffic on soils sensitive to compaction.

Cost-benefits

To the farmer

The trailing shoe is an expensive technology to adopt. In the absence of grant aid, purchase costs of trailing shoe tankers are approximately three times that of splashplate tankers of equal capacity. This means that the technology will be more suited to contractors rather than farmer-owned units.

The quantifiable benefits to the farmer will be the economic benefits of reducing N fertiliser costs through the increased slurry NFRV from trailing shoe application. With a potential economic benefit of €0.44/m³ slurry, adoption of trailing shoe on a 100-cow dairy farm (producing approximately 600m³ of slurry) could save the farmer approximately €260 per year. However, this saving will be quickly absorbed by the increased costs of the trailing shoe. The economic benefit of switching from summer to spring application is greater at €0.80/m³, and would correspond to €480 for the same farm. The switch in application timing

Conclusions

- Slurry application that is targeted towards optimising weather conditions that result in reduced ammonia losses can help reduce fertiliser N costs. Such conditions are normally more prevalent in spring;
- the monetary benefit from fertiliser N savings of switching to trailing shoe application without also switching application timing is marginal;
- by reducing grass contamination, the trailing shoe system can increase the flexibility of slurry application, and help to apply slurry when timing and weather conditions are optimal;
- the largest benefit of trailing shoe is seen when slurry NFRV is improved through both trailing shoe adoption and switching application timing;
- other benefits of trailing shoe adoption, such as reduced odours, may be of significant value in individual cases; and,
- umbilical application systems, or improved tyre specification on tankers, are also effective methods for improving the opportunity for spring application.

from summer to spring with the same application method would be at no extra cost, so spring application should be a priority wherever possible.

The largest economic benefit of trailing shoe adoption to the farmer comes when spring application can be facilitated where it was previously restricted by splashplate application. In such situations, the economic benefits of both trailing shoe adoption and spring application are additive, and trailing shoe adoption is economically justified. However, the economic benefits of other means of facilitating spring application (umbilical system, tyre specification) are also worth considering.

National

On a national scale, there are a number of benefits to trailing shoe adoption. Approximately 30 million m³ of slurry are produced in Ireland each year. The national benefit of switching to trailing shoe from improved NFRV would be approximately 11,110 tons of fertiliser N, with a current economic value of €13.3 million. The cost of national adoption of trailing shoe at contractor level can be estimated from the number of machines that would be required to spread all the slurry in the country. Assuming an output of 7,500m³ slurry per machine per year (300 hours at 25m³ per hour), to spread all the slurry in the country, 4,000 machines would be required. The average cost of each machine is approximately €40,000. If the average lifespan of each machine is eight years, the cost (excluding interest, and the increased maintenance and operational costs) would be €5,000 per machine per year. This gives a total national cost of €20 million per year.

This national cost assumes that all slurry would be applied by contractors. In reality, some farmers will continue to purchase their own equipment. This will increase the number of machines required, thus further increasing the cost on a national scale of trailing shoe adoption. The national cost of switching to spring application would be minimal, but would still provide many benefits, including fertiliser savings, and reduced ammonia and nitrous oxide emissions. Improved NFRV of slurry through either spring application and/or trailing shoe adoption will reduce national emissions of ammonia and nitrous oxide. Each one ton reduction in N fertiliser consumption results in reduced nitrous oxide emissions, corresponding to a potential saving to the Irish taxpayer of €107 in carbon taxes. Also, the trailing shoe application method results in decreased odours from slurry application.

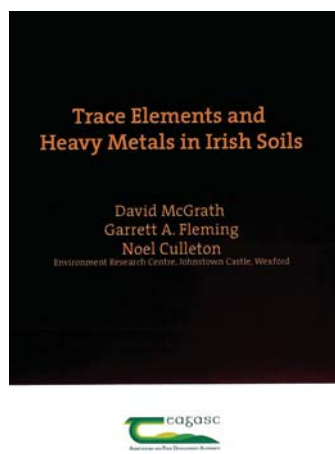
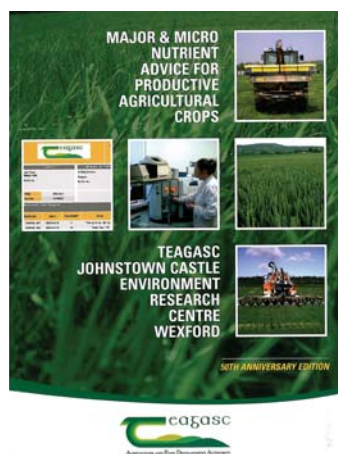
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Nutrient use on farms

Johnstown Castle Environment Research Centre has recently launched two books that provide essential information on Irish soils and the use of fertilisers.



Rising prices of fertilisers and concerns about air and water quality are forcing farmers to look very carefully at their fertiliser usage. Is it possible to maintain yields and use less fertiliser? Can slurry be used more effectively on farms? Can proper use of trace elements reduce fertiliser bills?

These issues are addressed in two books recently published by Teagasc, Johnstown Castle Environment Research Centre, which bring together knowledge from over 50 years of soil research at the centre. The first book is the third edition of the *Major and Micro Nutrient Advice for Productive Agricultural Crops*, commonly known as the 'Green Book', which has been an essential resource for farmers and agricultural advisers. A major objective of this revision was to ensure that it was comprehensive, and that it contained sufficient information to allow agricultural and farm advisers and consultants to recommend optimum levels of major and micro nutrients for the most important agricultural and field horticultural crops. The manual sets out to minimise conflicts between the need to ensure an economic return from grassland and tillage farming on the one hand, and growing concerns about losses of nutrients to water or gaseous emissions to the atmosphere, on the other.

Protection of waters

Many of the changes in this third edition were made necessary by legally binding requirements of the statutory instrument (SI) 378 of 2006 – the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006. This SI has major implications for use of N and P in farming, both for the farmer and for organisations and advisers recommending levels of nutrient use for agriculture. Before the SI was enacted, Teagasc nutrient advice involving N and P was determined by the level of these nutrients that gave the economic

optimum yield of the crop or grazing livestock in question, having regard to other factors, such as the risk and consequences of losses to the environment and/or the needs of subsequent crops in the rotation. From August 1, 2006, it is also necessary to ensure that the advice on the use of N and P for grassland and crops does not exceed the maximum levels specified by the statutory instrument for the crop and/or stocking rate concerned.

There is a new section on nutrient management in organic agriculture, which sets out the precepts of 'certified organic agriculture', and explains how the nutrition of organic crops relates to the generality of nutrient advice for Irish agriculture.

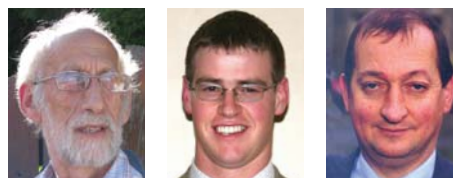
Trace elements

The second book is entitled *Trace Elements and Heavy Metals in Irish Soils*. This volume is a compilation of existing collated information on trace elements/heavy metals in soils, plants and food, and contains information presented in the past by Johnstown Castle staff, which is largely relevant to Ireland.

In recent years, most of the focus of research on fertilisers has been on the major nutrients and their effects on productivity and on the environment. The role of trace elements has received very little attention. Yet, trace elements are absolutely essential for healthy plant and animal growth. The principal trace elements for healthy plant growth are: iron, manganese, copper, zinc, boron, molybdenum and chlorine. In addition, there are other nutrients that are essential for animal nutrition, but not for plant nutrition: these include sodium, selenium, cobalt, iodine and chromium, and are normally supplied to animals by the plants they eat.

Much of this information still exists in hard copy but is becoming less easy to access and is in danger of being lost. This information is as relevant today as when it was first compiled. The principal objective in producing this compilation is to ensure that the information is made available to Teagasc staff and to researchers with an interest in trace elements/heavy metals in an Irish context.

Brian Coulter is a Principal Research Officer, **Stan Lalor** is a Research Officer and **Noel Culleton** is Head of Centre at Johnstown Castle Environment Research Centre, Wexford. E-mail: noel.culleton@teagasc.ie.



Innovation on Irish farms



KEVIN HEANUE presents initial research findings of a broad 'Economics of Innovation' project in the Rural Economy Research Centre. This research is timely, as innovation is increasingly viewed as a critical driver of economic growth and development.

This article reports some preliminary findings of an analysis of farmer innovation that is part of a broader research project – Economics of Innovation – being carried out at the Teagasc Rural Economy Research Centre (RERC), Athenry. This research is timely as innovation is increasingly viewed as a critical driver of economic growth and development across all sectors of the economy, including farming and the broader agrifood industry.

Innovation depends on knowledge. In turn, knowledge develops through learning.

Although the concept of innovation is not new within the social sciences, it has experienced something of a renaissance in recent years with more research attention directed towards it. Even outside the research environment, the 'need for us all to be innovative', is regularly discussed in the media. However, there is often a lack of clarity about what is actually meant by innovation, why it is important and how much of it is going on. This article describes how this research project is addressing those questions in relation to Irish farms. In particular, it outlines some preliminary results about the extent of innovation in Irish farming and identifies other issues that the project will examine.

What is innovation?

Innovation is 'profitable novelty'. Both parts of this definition are important. For any enterprise, the key feature of an innovation is that it confers a temporary monopoly on the enterprise relative to its competitors, which increases profitability at least for a period of time. In this sense, it is distinct from invention. Invention is the generation of an idea, but innovation only occurs when the idea is actually put into practice or, from a business point of view, is commercialised. Within innovation studies, there are four different types of innovation that are considered important – the introduction of new products; new methods of production; expansion into new markets; and, development of new ways to organise business. In addition, we are usually interested in such innovations as long as they are new to the particular enterprise or farmer that we are analysing, whether or not the products, processes, markets, or organisational forms are necessarily new to other farmers.

At first glance, such a broad view of innovation may seem odd; however, this broad conceptualisation of innovation is now standard in much innovation-related analysis and is similar to that used by the EU Community Innovation Survey, and forms the basis of the OECD's Innovation Manual. However, up until now it has rarely been applied to the farming sector. The reason we use this broad definition is that, contrary to popular opinion, most innovations are not 'radical' or completely new products or processes. The majority of innovations in all areas of economic activity are 'incremental' – small ongoing changes to products or processes, or ways of organising businesses or marketing goods and services – and the bulk of economic benefits come from such incremental innovations and improvements. We are interested in the 'newness' aspect, because this implies that new knowledge is being used by that particular farmer. Knowledge is important because it underpins the ability to combine all the traditional factors of production (land, labour and capital) in new ways to provide an ever-expanding supply of value-added goods and services.

Why are we interested in innovation?

We can study farmer innovation for a variety of reasons. To take just three examples, we might be interested in:

1. tracing the impact of a specific innovation on farm productivity or efficiency;
2. identifying how fast an innovation diffuses through a community of farmers; or,
3. understanding how, why, and from where farmers get the new knowledge that underpins their innovative activities, the type of knowledge that is important for them and what hinders or helps their access to this knowledge.

This latter focus is driving the current phase of research taking place within this project in RERC.

As outlined above, it is clear that innovation depends on knowledge. In turn, knowledge develops through learning. Learning includes those processes that lead to the creation of new knowledge, and those processes that spread existing knowledge to new persons. For example, farmers' learning might include various activities, ranging from attending education courses to getting advice about something new from an organisation or person who is knowledgeable about it, or working with someone who is using a new product or process, or implementing a new management system, or using a new process or product for the first time and solving problems as they arise. These activities are commonly known as learning by searching, learning by interacting, learning by doing, and learning by using, and are considered important for innovation. Therefore, in researching innovation, we are really interested in understanding the types of knowledge and learning processes that underpin different types of innovation. Ultimately, what is important from Teagasc's point of view is to try to gain an understanding of what types of learning are important, how that learning is promoted, and through what activities Teagasc can assist in the processes of learning?

Data and preliminary findings

The data on farmer innovation was gathered as part of the Supplementary National Farm Survey carried out by the National Farm Survey (NFS) Unit, RERC, in Autumn 2007. A sample of 1,052 farmers was asked questions about the type of innovation they were engaged in. In addition to the four different types of innovation outlined above, one other type of innovation activity was added. Farmers were asked whether they engaged in a new off-farm activity. An overview of the results is presented in **Figure 1**.

It appears that the tillage and dairy sectors record the highest levels of innovation. Figure 1 also confirms that organisational and process innovations are the most common types of innovation for each of the four main farming systems. However, there are some differences. In the dairying, cattle and sheep sectors, organisational innovation is most common, followed by process innovation. In the tillage sector, process innovation is the most commonly recorded, followed by organisational innovation.

What are the implications of these findings?

The initial results from this research identify the types of innovation being carried out on Irish farms. It shows that the most frequent type of innovative activity relates to organisational and process issues. The next stage of the research will develop a more comprehensive profile of those farmers who are innovating and those who are not. Factors that are likely to influence the propensity of farmers to innovate include the farmer's age, farm size, whether or not they are clients of Teagasc, whether the farmer is full-time or part-time, the education level of the

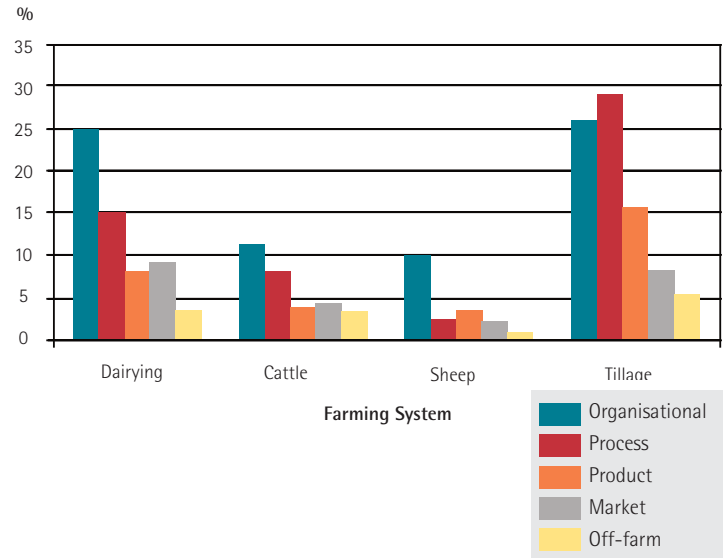


FIGURE 1: Innovation within different farming systems.

farmer and the interaction of the farmer with discussion groups and monitor farms, for example. After that, further analysis will be needed to identify where farmers get their ideas and information from, and to clarify what type of information, knowledge and advice they need. Taken together, these analyses will give an insight into farmers' learning processes.

Concluding remarks

It should be clear that as this research progresses more information will become available on the types of knowledge that are important for farmers' ability to innovate, and also the learning processes that underpin this knowledge use. Therefore, this research will complement two other specific pieces of work being carried out by Teagasc PhD Walsh Fellows within the broad 'Economics of Innovation' project at RERC. The first piece of research is looking at the learning process from monitor farms to the wider farming community. The second topic is examining knowledge transfer to farmers within the activities of Teagasc's Business and Technology Advisory service. Combining the outcomes of the three pieces of work over time should help to clarify many issues surrounding farmer innovation and learning.

Acknowledgements

I would like to thank my colleagues in the NFS Unit in RERC, Athenry, for their co-operation in implementing the Supplementary NFS questions, and all the recorders and farmers who generated the data.

This research is funded by the Teagasc Core Programme.



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Moorepark cheese research highlights 2000-2008



Image courtesy of Bord Bia.

TOM BERESFORD and TIM GUINEE, Moorepark Food Research Centre, explain how cheese research has benefited the Irish dairy industry and that huge potential for the industry still lies ahead.

In 2000, approximately 20% of Irish milk was used in cheesemaking compared to 48% across the EU15 countries; moreover, Cheddar was the major type of cheese produced. Against the backdrop of impending trade liberalisation and declining price supports for dairy commodities (GATT/WTO in 1995, EU Agenda 2000 Agreement [1999]), Ireland's product mix was becoming less favourable in profit terms. A move from subsidy-supported commodity ingredients towards non-subsidised products showing a strong demand in growth would be more opportune. Cheese production expanded by 2.6% globally between 1995 and 2000, but ranged from about 1.6% in the EU15 to about 11% in Australia and New Zealand. Hence, the Strategic Development Plan for the Irish Dairy Processing Sector (Prospectus, 2003) identified cheese as a strategic product to be "pushed", and stressed that the market opportunity would depend on our ability to provide a range of cheese products and market messages to meet the demands of the evolving retail and food service markets.

Funding for cheese research 2000-2008

The Agri-Vision Committee (2004) recommended increased collaboration between the research institutes (Teagasc and the universities) and Irish food companies so as to foster market-led R&D. A key source of funds to support such collaboration is the Food Institutional Research Measure (FIRM), operated by the Department of Agriculture, Fisheries & Food as part of the National Development Plan. Funding made available through FIRM, augmented principally by the Dairy Research Trust Levy (a programme funded by farmer producers), enabled research teams in Teagasc and the universities to build a cheese programme around five main areas, i.e., manufacturing efficiency, product diversification, flavour development, texture and functionality, and secondary processing, as prioritised through discussions between industry and the institutions (**Table 1**).

Cheesemaking efficiency

Manufacturing efficiency is of critical importance to commercial success, and research in this priority area focused on: benchmarking Cheddar cheesemaking efficiency; establishing the effects of variations in key manufacturing parameters; and, developing prediction equations relating cheese yield to composition of milk and component recoveries.

A three-year survey (2001-2003) indicated significant inter-company differences in fat recovery from milk to cheese and in cheese composition. Fat losses in the

TABLE 1: Cheese programme at Moorepark Food Research Centre 2000–2008: programme areas, project titles (dates), and funding source.

Project No.	Programme area Project title	Funding source
1	Cheesemaking efficiency Factors affecting cheddar cheesemaking efficiency (2001–2004).	FRM/Dairy Levy
Cheese diversification		
2	Evaluation of the effect of varying technological parameters of cheesemaking on the ripening and consumer acceptance of novel cheeses manufactured using Cheddar type equipment.	FRM
3	Development of cheese varieties with flavour and functional attributes suitable for evolving consumer markets (2005–2008).	Dairy Levy
4	Development of a range of innovative, high-quality value-added specialty meat and cheese products.	InterReg IIIA Community Initiative Programme
Flavour systems		
5	Development of a highly functional cheese sauce incorporating novel enzyme-modified cheese (2004–2006).	FRM
6	Identification and elucidation of novel enzymatic activities and the development of novel biotechnological processes for the generation of flavour in cheese (2004–2006).	FRM
7	Biodiversity of cheese microflora and its role in cheese flavour development (2000–2003).	FRM
8	Complete genetic make-up of <i>Lactobacillus helveticus</i> DPC4571: a strain for improved cheese flavour (2002–2004).	FRM
9	Role of lipolysis in biogenesis of cheese flavour (2001–2004).	FRM
10	Understanding the biochemistry and enzymology of cheese ripening and development of novel strategies to enhance the biogenesis of cheese flavour (2005–2007).	FRM
Cheese texture and functionality		
11	Improving the functionality of reduced fat pizza cheese (2001–2004).	FRM
12	Effect of composition on the viscoelasticity and functionality of cheese (2000–2004).	USDA Foreign Agricultural Service ¹
13	Cheese 2030 – New technology platform for engineering cheese structure and function in model systems (2008–2011).	Enterprise Ireland ²
14	Secondary cheese processing Secondary cheese processing (2005–2008).	Dairy Levy

¹ USDA Foreign Agricultural Service (US/Ireland co-operation program)

² Enterprise Ireland, Commercialisation Fund–Technology Development

vat and curd pumping were the most significant and most variable. Inter-company variations were attributed to plant technology, equipment maintenance and operational practices. The mean fat recovery increased by 2.5% in response to observations during the course of the survey.

Milk protein level, protein-to-fat ratio, and firmness at cutting were found to have major impacts on rennet gelation characteristics, component recoveries, cheesemaking efficiency, and cheese composition. Our studies proposed an integrated approach to optimise manufacturing efficiency, involving standardisation of milk protein level, protein-to-fat ratio, firmness of gel at cut, ratios of rennet and starter activities to casein, and pH at different stages of manufacture, including the use of advanced sensor technology to monitor key process parameters. Such an approach should also incorporate the use of plant-specific prediction equations as a means of continually charting actual yield efficiencies relative to predicted efficiencies.

Cheese diversification

It is now generally accepted that increasing cheese manufacture in Ireland will require an expansion of the assortment of cheese products to meet emerging market demands for diversity (Prospectus, 2003). These demands will include variants on Cheddar for both table and ingredient markets, but also the establishment of the technology to manufacture selected continental cheese varieties in Ireland from a seasonal milk supply. Thus, the strategy at Moorepark Food Research Centre (MFRC) is to develop the core technological expertise necessary to support the development of such cheeses.

Consumer market studies identified a number of cheese types that demonstrated market potential. These included sweet-, blue-, and Mediterranean-style cheeses, many of which are traditionally manufactured using goat or sheep milk cheeses.

A range of novel sweet-hybrid type cheeses was developed at pilot scale through alteration of key compositional, processing and ripening variables. These cheeses were designed for manufacture in Cheddar plants to fit in with current manufacturing infrastructure. Blue Cheddar-type cheeses were also developed. Manufacture of Mediterranean-type cheeses with partial or total substitution of sheep/goat milks with cow milk was also investigated. Consumer focus groups identified the most promising cheeses and scale-up of several of these was undertaken by commercial companies.

Cheese flavour systems

Flavour is a key quality indicator, dictating consumer repeat purchase, and the ability to alter and accelerate flavour development has long been a goal of the cheese industry. Flavour development in cheese results from a complex series of chemical and biochemical interactions, of which there is currently only limited understanding.

Our research has identified several strains of *Lactobacillus helveticus* that impart sweet and nutty flavour notes. One strain, *L. helveticus* DPC4571, for which the complete genome sequence was reported, has significant commercial potential. In addition, strains of non-starter lactic acid bacteria and surface smear organisms have been identified with the capacity to diversify cheese flavour. Lipolysis was identified as a key flavour pathway in Cheddar cheese, with starter lactic acid bacteria being the primary source of esterases responsible for the production of free fatty acids that contribute to flavour. Contrary to previous opinion, most lipolytic activity was found to occur in the vat rather than during

ripening. Seasonality of milk had a major impact on the extent of lipolysis; by contrast, there is little contribution from adventitious non-starter lactic bacteria or from indigenous milk lipoprotein lipase, which was inactivated by pasteurisation.

Enzyme modified cheeses (EMCs) are concentrated cheese flavours that offer a cost-effective alternative to natural cheese as a source of cheese flavour in a range of formulated food products. A new process was developed to produce EMCs with more specific flavours and to provide a platform for a new generation of natural enzyme-modified dairy products suitable for clean label food applications. Key aspects of the process involve: the use of caseins and anhydrous milk fat as substrates; separate fermentation of these substrates followed by their blending; utilisation of starter lactic acid bacteria in tandem with exogenous enzymes; and, modification of the blend to reduce losses of key volatile compounds during subsequent drying.

Cheese texture and functionality

The programme focussed on development of new insights and approaches to ingredient cheeses for the food service sector. The texture of half-fat Cheddar (15%, w/v, fat) was improved significantly by increasing the degree of *in situ* whey protein in milk (via elevation of pasteurisation temperature) and using an exopolysaccharide-producing starter culture adjunct. The melt properties of the cheese decreased significantly beyond a critical level of whey protein denaturation (>13% of total whey protein). This provided an effective tool to modulate the degrees of melt, as required in different applications.

A Moorepark method was developed for the manufacture of half-fat Mozzarella (approximately 10% fat) with cook properties similar to that of control (21% fat) Mozzarella. Key features of this process included reducing the degree of calcium-induced aggregation of the cheese protein, casein, and increasing casein hydration.

Secondary cheese processing

Processed cheese products (PCP) are prepared by blending and heating cheese, emulsifying salts, water and optional ingredients. They are popular as ingredients in the food service and food formulation sectors, where functionalities (e.g., controlled melt) customised to specific applications are critical. The aim of our research was to gain more insight into the basic mechanisms controlling the functionality of these products. Alteration of the calcium-to-casein ratio of cheese, degree of casein hydrolysis, and processing conditions (shear, temperature and time) were found to be key determinants of functionality. They exert their effects primarily by altering the degrees of protein hydration and fat emulsification. A further aspect of the research examined cheese base (a stabilised cheese preparation) as a replacement for natural cheese in PCPs. This led to the development of a novel approach to cheese manufacture, which was patented in 2008. The process involves the manufacture of cheese from reassembled milks prepared from reconstituted designer dairy ingredients, with little, or no, whey separation. Research in this area is continuing within a new project funded by Enterprise Ireland.

Conclusions

In summary, the public funding made available to support cheese research during this period has enabled continued development of a cheese programme at Moorepark that responds to industrial needs, while laying foundations in science and technology that will assist the future expansion and development of the industry.



Tom Beresford is Head of the Food Cultures and Safety Department, and **Tim Guinee** is a Principal Research Officer in the Food Processing and Functionality Department, Teagasc Moorepark Food Research Centre. E-mail: tim.guinee@teagasc.ie.

Technology promotion: novel cheese-making technology

Of interest to:

- manufacturers of specialised dairy ingredients and ingredient cheeses for the industrial and food service sectors;
- manufacturers of ingredient cheeses with customised physical properties and in-built cost efficiencies; and,
- companies interested in the health cheeses market, with added bioactives and prebiotics.

Technology on offer

A novel cheese-making technology without a whey drainage step, based on prototype novel micellar casein and milk protein concentrate powders, with different calcium-to-casein ratios, buffering capacity, and casein-to-whey protein ratios.

IP status

A patent application covering novel micellar casein powders and related cheeses was filed in June 2008.

Competitive advantage

- Precise control of composition and calcium levels leading to customised physical and sensory properties in final cheese products;
- potential for in-built cost efficiencies for food service sector;
- potential for development of new generation health cheeses; and,
- enhanced opportunity for manufacture of specialised dairy ingredients suited for inclusion in novel cheese preparations.

Stage of development

Initial research was funded by the Dairy Levy Fund, while further research underway in Teagasc with a view to process optimisation is being funded by the Enterprise Ireland Commercialisation Fund.

For further information please contact Miriam Walsh, Teagasc Intellectual Property Officer, T: 059 918 3477, E-mail: miriam.walsh@teagasc.ie.



Aberdeen Angus cattle.

Better beef – bridging the gap between expectation and satisfaction

Have you ever bought beef, cooked it and, upon tasting, discovered that it was unsatisfactory? Have you ever been reluctant to order beef in a restaurant in case it is tough? Beef by nature is inconsistent; we have safe beef, and we have excellent quality beef, but we don't have consistently excellent quality beef. Researchers at AFRC are trying to rectify this.

Before purchase, quality expectations influence the selection of meat, and these are formed on the basis of the available quality cues, which are either intrinsic or extrinsic. Intrinsic cues are physical product characteristics and cannot be changed without changing the product itself. For beef, the intrinsic cues used to determine quality at point of purchase are misleading in terms of palatability. For example, Irish consumers currently select beef according to its redness. However, apart from dark firm and dry beef (DFD), which is a problem usually associated with animal stress, colour is a poor indicator of palatability. Another example of the potentially misleading cues used at point of purchase is the level of visible fat, which, in Ireland, has a negative impact on quality expectations but a positive impact on palatability. As it is difficult to judge beef through intrinsic cues at point of purchase, extrinsic cues are increasingly important in forming consumers' expectation of beef quality. Extrinsic cues are related to the product but are not physically part of it, such as brand name, labels, presentation and price.

Consumer satisfaction depends on the extent to which the product meets their expectations and a repeat purchase is unlikely if the sensory properties do not

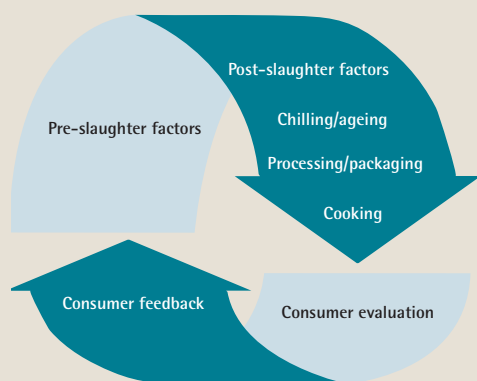


FIGURE 1: Diagram illustrating PACC solution to producing consistent eating quality.



Hot-boning the striploin from a carcass, an early post-mortem process with effects on eating quality.



Striploin being inserted into Pi-Vac® packaging system. A novel early post-mortem technique that may alleviate the toughening effect of hot-boning.

meet with these expectations. Guaranteeing consumer satisfaction is problematic due to inconsistency in palatability and lack of reliable quality cues. It would be beneficial to use a brand or label that accurately relays intrinsic information in a consumer-friendly manner. This would enable consumers to form accurate expectations, which would improve satisfaction by reducing the difference between expected quality and experienced quality. These palatability cues must be consistently accurate in order to reduce perceived risk and gain consumer confidence. This is a challenging task due to the inconsistent nature of beef itself.

Reducing variation by eating quality classification

Beef is biochemically dynamic; hence, it is naturally susceptible to variation in palatability, which is evident in the marketplace. This variation in palatability stems from a wide range of factors along the supply chain from farm to fork. For example, breed, sex, age at slaughter, and the use or not of intervention techniques post-slaughter (such as electrical stimulation, hanging techniques and chilling regime) all influence palatability. The selection of beef cut by consumers at point of purchase, combined with cooking method, also has an effect on variation in palatability. Controlling this variation is a complex task. Accurate prediction of eating quality before consumption would be beneficial, as it would allow beef to be classified according to palatability. Currently in Ireland, beef carcasses are classified according to the Official EU scheme (EC 1208/1981) for conformation and fat cover. Although the introduction of automated grading equipment using computer vision technology has removed subjectivity in carcass grading, these characteristics are related to the value of the carcass through their effects on saleable yield, but are not strongly related to eating quality. In order to

improve the consistency of beef eating quality, there is a need for a new grading system that takes into account not only differences between carcasses, but also differences in the palatability of individual cuts. This would aid the conversion of intrinsic cues to extrinsic cues, thereby increasing consumer satisfaction through a closer match between before and after consumption evaluations.

The PACC solution

Meat and Livestock Australia developed a meat grading scheme called Meat Standards Australia (MSA). This programme adopted consumer testing as a measure by which to evaluate the effectiveness of a grading system and as a tool to develop a detailed understanding of factors that interact to determine the eating quality of individual beef cuts. The MSA grading scheme is based on the principles of Palatability Assurance at Critical Control Points (PACC). Researchers at Ashtown Food Research Centre are currently using this system to carry out consumer taste panels with the aim of developing a similar grading system here.

The objective is to identify and carefully control production and processing factors that have the largest effect on palatability, so that it is possible to accurately predict the quality of the final product. Consumer feedback should guide industry to tease out those parameters that result in inconsistent beef palatability. The PACC system also leaves scope for the improvement of meat quality rather than prevention of bad meat quality alone. This can be achieved by incorporating novel intervention techniques into factory procedures. For example, the introduction of the Pi-Vac® packaging system alleviates the contraction of pre-rigor beef, hence alleviating the toughening effect. This may lead to



Various cuts of beef cooking on a grill for consumer analysis.

increased production of premium quality beef, which could be labelled and priced as such, and could also allow for the development of differentiated products in terms of non-economic factors, which can then be promoted to specific market segments. Consumers in this study stated that they are willing to pay a higher price for better palatability.

Consumer-led research

In order to develop a consumer-led quality assurance scheme, it is vital to assess consumers' current knowledge of beef eating quality, most importantly their use of intrinsic cues so that they can be conveyed as extrinsic cues that are easily recognised by the target consumer group. Research at Ashtown found that consumers accurately ranked palatability attributes according to the quality of the beef consumed regardless of cooking type. For example, beef described by consumers as 'good everyday eating quality' consistently scored significantly higher for all palatability attributes than that rated 'unsatisfactory'. The fillet was ranked as significantly better quality for all palatability attributes when compared to the other cuts, even though consumers did not know from which muscle each sample came (the fillet was the most valuable of the cuts that consumers tasted). Thus, Irish consumers have a good understanding of, and are consistent in determining, the palatability factors that constitute beef quality.

Implementation

Implementation of the PACCP plan would be beneficial to Irish consumers as it has the potential to predict eating quality using consumer feedback. By building on consumers' knowledge of palatability, product differentiation – through branding or other extrinsic cues – may improve value recognition in retail

Interested in taking part in this study?



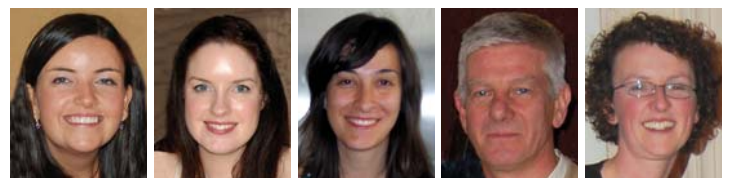
Taste panel booth.

We are currently recruiting groups of 20 consumers to participate in taste panels. If you are interested, and would like to raise some funds for a club, society, or fundraising for charity, please contact Annamarie White on 01 805 9990 or E-mail: annamarie.white@teagasc.ie.

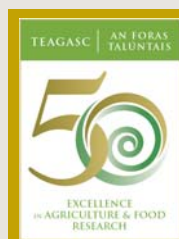
situations. This would help consumers to link post-purchase evaluations with pre-purchase evaluations. Further research should focus on communicating palatability through easy-to-recognise extrinsic cues such as a labelling system, and ensuring that these cues accurately and reliably describe the objective eating quality of a particular piece of beef. Future work should focus on what type of labelling system would satisfy the needs of consumers, producers and retailers.

This research is funded by the Department of Agriculture, Fisheries and Food FIRM programme.

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T Events



This year marks the 50th anniversary of AFT (now Teagasc). AFT 50 events will take place at all Teagasc research centres, and at the events marked below. A DVD marking the anniversary will be launched at the Foresight conference and a commemorative book will be launched in September. There will also be a lecture series.

Events highlighted are part of the celebrations.

August

August 5-9 *University College Dublin*

42nd Congress of the International Society for Applied Ethology

The ISAE provides technical evidence on topics relating to animal behaviour and animal welfare, contributing to policy and regulations at national, European and international level.

laura.boyle@teagasc.ie www.isae2008.com

August 24-27 *University College Cork*

International Agricultural Biotechnology Conference

Hosted by Teagasc Oak Park, the theme for this year's conference is 'Agricultural biotechnology for a competitive and sustainable future'. The conference is the largest agricultural biotech conference in the world and provides a unique opportunity for Irish academia and business sectors to discuss the issues, options and challenges being met by the biotechnology industry.

The many topics under discussion will include innovations in areas such as biofuels and bioenergy, animal and plant breeding, fisheries biotech, molecular pharming, dairy and food, including dedicated sessions on policy, regulatory affairs and business strategies. T: +353 1 206 2900
info@platinumone.ie www.abic.ca/abic2008.html

September

September 4 *Teagasc Oak Park, Carlow*

Potatoes '08 The Quest for Quality

This open day will give potato growers practical advice on producing quality potatoes for all markets.

denis.griffin@teagasc.ie www.teagasc.ie/events

September 24-25 *Ashtown Food Research Centre*

Complaints and Crisis Management

Food companies will learn from case studies how to handle complaints, understand risk assessments and the methods for successful product recall planning. T: +353 1 805 9572

carmel.farrell@teagasc.ie www.teagasc.ie/ashtown

September 30 *University of Limerick*

Exploiting the nutrients of fruits, vegetables and herbs

This workshop will describe the nutrients contained in fruits and vegetables and their associated healthy components; present research on ways to optimise antioxidant levels during harvesting and processing of fruits, vegetables and herbs; and, highlight future trends in fruit and vegetable consumption.

In relation to herbs, the growing conditions, extraction process and concentration of the antioxidants will be discussed.
info@relay.teagasc.ie www.relayresearch.ie

October

October 3-November 27 *Kildalton, Gurteen College, Botanic Gardens, Warrenstown, 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

October 14 *Ashtown Food Research Centre*

Sensory Analysis Training Course

Practical training on the principles of sensory analysis. Training takes place in a fully computerised state-of-the-art sensory analysis laboratory. Funding may be available. Jointly presented by AFRC and St Angela's Food Centre, Sligo.

T: 01 805 9536
aine.sommerfield@teagasc.ie www.teagasc.ie/ashtown

October 20, 21 and 22 *Moorepark (20th), Kilkenny (21st) and Cavan (22nd)*

National Pig Conference

Topics that will be covered include: use of antibiotics; lactation feed intakes; pig and feed price prospects; and, welfare codes and compliance.

November

November 9-16 *Teagasc research centres nationwide*

Science Week

This year's theme is 'Science is all around us'. Teagasc research centres will hold open days for secondary school students. There will also be a series of events aimed at the adult audience in conjunction with the Irish Science Open Forum.

The Walsh Fellowships seminar will take place on November 12 at the RDS (siobhan.culleton@teagasc.ie).

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 the RDS Agriculture and Rural Affairs Committee at 6.00pm (contact gerard.whelan@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

www.teagasc.ie/events

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