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T Research

Research and innovation news at Teagasc

Improving farm safety – getting inside the mind of animals

Food choices – what's my motivation?
Dairy bull beef production
Nutrient loads from agri-catchments

teagasc
Agriculture and Food Development Authority

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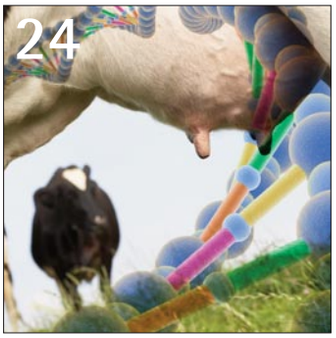

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Cover image based on Professor Temple Grandin's design.

Credits

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

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T Editorial

Funding for food, agriculture and forestry research

The Minister for Agriculture, Food and the Marine, Simon Coveney, TD, recently announced the successful projects in food, agriculture and forestry research resulting from the 2010 FIRM/Stimulus/COFORD call. The 23 research projects will be undertaken by 13 research institutions and Teagasc researchers will be involved in 16 of these projects, which is an excellent performance by our researchers.

The research being undertaken in these projects is important for the development of the agri-food industry, and particularly to help deliver the *Food Harvest 2020* targets. This funding will build expertise and capacity in important areas and deliver useful research to support innovation in the industry. Given the current economic situation, this funding is a vote of confidence in the industry by the Government and in the capacity of research to deliver valuable knowledge to support innovation in the industry.

One of the largest awards is for a new national cheese research programme. The Teagasc food research team leading this programme will be working closely with University College Cork, University College Dublin (UCD), the Agri-Food and Biosciences Institute (AFBI) in Northern Ireland and the University of Limerick (UL) in research to underpin the competitiveness of Irish cheese production. Given the increased volumes of milk expected after milk quotas end, this research is very timely.

The challenges facing Irish agriculture from gaseous emissions are being addressed collectively through research by Teagasc in collaboration with UCD, Trinity College Dublin, National University of Ireland Maynooth, UL and the AFBI. A new national network of leading scientists from across these institutions and led by Teagasc is being established with funding from the Stimulus programme. This research will focus on mitigation strategies for methane and nitrous oxide emissions from agriculture.

The Minister also launched two strategy documents to guide the FIRM and Stimulus calls for the future. Food Research Ireland and Stimulating Sustainable Agricultural Production through Research & Innovation are strategic research agendas that were developed by expert groups representing industry, researchers and policy makers. They set out priority areas for future research and are important statements of the research needs of the agri-food industry.

Dr Frank O'Mara
Director of Research

Maoiniú faoi choinne taighde bia, talmhaíochta agus foraoiseachta

D'fhógair an tAire Talmhaíochta, Bia agus Mara, Simon Coveney, TD, na tionscadail rathúla i dtaighde bia, talmhaíochta agus foraoiseachta i dtaca le glaoch 2010 FIRM/Stimulus/COFORD. Tabharfaidh 13 institiúid taighde faoi 23 tionscadal taighde. Beidh taighdeoirí ó Theagasc páirteach i 16 cinn de na tionscadail seo. Is éacht an méid sin ag na taighdeoirí againne. Tá an taighde a dhéanfar mar chuid de na tionscadail seo tábhachtach i dtaca le forbairt an tionscal agraibhia, agus beidh sé ina chuidiú le spriocanna *Fómhar Bia 2020* (*Food Harvest 2020*) a ghnóthú. Mar gheall ar an mhaoiniú a chuirfear ar fáil, cuirfear le saineolas agus le hinniúlacht i réimsí tábhachtacha agus déanfar taighde a chuirfidh leis an nuálaíocht sa tionscal. Nuair a thugtar san áireamh an dóigh a bhfuil cúrsaí eacnamaíochta faoi láthair, is léir gur léiriú é an beart maoinithe seo ar an mhuinín atá ag an Rialtas as taighde mar uirlis le heolas luachmhar a chur ar fáil a chuireann leis an nuálaíocht sa tionscal. Baineann ceann de na damhachtainí is mó le clár nua náisiúnta taighde ar cháis. Is í meitheal taighde Theagasc ar bhia a bheidh i gceannas ar an chlár áirithe seo. Oibreoidh siad go dlúth le Coláiste na hOllscoile, Corcaigh, le Coláiste Ollscoile Bhaile Átha Cliath (COBÁC), leis an Institiúid Agraibhia agus Eolaíochtaí Bitheacha (IAEB) i dTuaisceart Éireann agus le hOllscoil Luimnigh agus déanfaidh siad taighde a chuirfidh bonn faoin iomaíocht i dtáirgeadh cáise in Éirinn. Is dóichí ná a mhalairt go mbeidh i bhfad níos mó bainne ar fáil nuair a thiocfaidh deireadh le cuótaí bainne, mar sin tá an taighde seo an-tráthúil.

Tá aghaidh á tabhairt ag grúpa institiúidí ar na dúshláin atá romhainn i gcúrsaí talmhaíochta mar gheall ar astuithe gás. Déanfaidh Teagasc taighde i gcomhar le COBÁC, le Coláiste na Tríonóide, Baile Átha Cliath, le hOllscoil na hÉireann, Maigh Nuad, le hOllscoil Luimnigh agus le IAEB. Tá gréasán nua náisiúnta de shaineolaithe ó na hinstitiúidí sin ar fad á bhunú, le maoiniú ón chlár Stimulus, agus is é Teagasc a bheidh i gceannas air. Díreoidh an taighde seo ar straitéisí le hastuithe meatáin agus ocsaíde nítriúla sa tionscal talmhaíochta a mhaolú.

Sheol an tAire dhá cháipéis straitéise chomh maith a bheidh mar threoir i dtaca le glaonna FIRM agus Stimulus sa todhchaí. Is cláir thaighde straitéiseacha iad Taighde Bia Éireann (Food Research Ireland) agus Táirgeadh Talmhaíochta Inmharthana a Spreagadh trí Thaighde agus Nuálaíocht (Stimulating Sustainable Agricultural Production through Research & Innovation). Is grúpaí de shaineolaithe as measc lucht tionscail, taighdeoirí agus lucht ceaptha polasaithe a d'fhorbair na straitéisí seo. Tá réimsí tosaíochta don todhchaí leagtha amach iontu agus tá ráitis thábhachtacha iontu maidir le riachtanais taighde sa tionscal agraibhia.

An Dr Frank O'Mara
Stiúrthóir Taighde

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T News

Researcher profile

Trevor Donnellan

Trevor is an economist in the Agricultural Economics and Farm Surveys Department at the Rural Economy Research Centre in Athenry.

His work programme includes a range of national funded and international EU Framework funded projects. He is part of the well known FAPRI-Ireland team, which analyses the future impact of changes in agricultural and trade policies on commodity markets and farm incomes. He is also involved in work relating to agriculture and the environment. This includes examining how emissions of greenhouse gases and ammonia may change into the future, and measuring the cost of dealing with emissions. Trevor studied and then worked at UCC before joining Teagasc in 1997. He was based at the Head Office in Dublin until the 'big move' to Galway in 2004 when the Sandymount office was relocated.

"Teagasc has relatively few economists so you need to try to keep abreast of a fairly wide range of topic areas, but in general my work tends to be very much forward looking. While everyone is interested in hearing what is likely to happen next month or next year, we are also interested in what the agri-food sector will look like a decade from now. I find that it's a lot easier to explain to people what I do nowadays. Ireland's recent economic difficulties have given the general public a greater interest in economics and a better understanding of why it is important to make projections about what the future will look like if this or that were to happen.

"I'm from Cork City so, unlike most Teagasc staff, I didn't have a background steeped in agriculture when I joined Teagasc. There was a steep learning curve in the early days but now I realise that being an outsider does have its advantages. It makes you very aware that people looking at the agricultural sector from the outside actually understand very little about the complexities of the sector. That's important to remember when it comes to communicating about agriculture with non-agricultural experts and the general public.

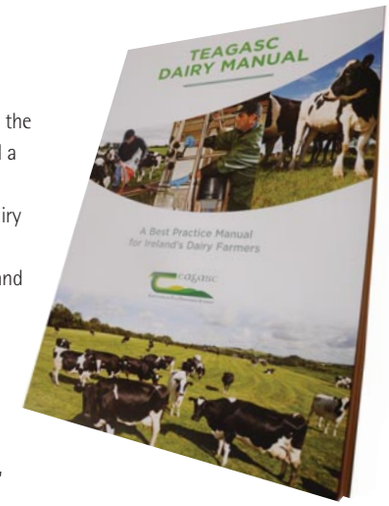
"What I enjoy most about my job is the variety of activities it brings. In economics we have quite a broad range of stakeholders – everyone from farmers to policy makers. One day you could be talking to people who are experts in the sector and the next day you could be dealing with people who have a very different level of understanding of agriculture. This means that no two days are the same. In addition, a good mix of my time is spent in and out of the office, and you get to meet a wide range of people, both in Ireland and around the world.

"Outside of work I like sport, travel and anything to do with technology. I think it's fair to say that I'm a bit of a sucker for gadgets!"

Advances in Cereal and Bakery Research

At the recent seminar, 'Advances in Cereal and Bakery Research – Challenges and Opportunities Facing the Industry', which was held in the Food Science and Technology Building, UCC, the results of recent research collaborations between UCC and Teagasc were presented, including research on salt reduction in cereal and baked products, and gluten-free and sourdough technologies. The researchers are also working on novel solutions to add value to nutritious cereal by-products and on developing cereal-based snacks with characteristics suitable for the elderly. Both UCC and Teagasc have developed solutions to produce gluten-free baked goods; they tested the suitability of a range of novel/functional ingredients including starches, gums, dietary fibres and dairy ingredients as replacements for gluten. Researchers are also looking at novel ways to utilise the nutritious by-products of food processing, in particular those generated from brewing, milling and cider processing, and aim to formulate new, healthy cereal-based snacks. By-products from these processes have been found to have a high quantity of healthy compounds (e.g., dietary fibre, antioxidants, polyphenols), but are still under-used in the food industry.

Teagasc Dairy Manual



As farmers begin to plan and prepare for the world post quotas, Teagasc has produced a comprehensive manual for existing and potential dairy farmers – the 'Teagasc Dairy Manual'. The Teagasc Dairy Manual is available at a cost of €50 plus postage and packing. The price for Teagasc clients is €25 plus p&p (€7.50). To order, contact Teagasc on 059-170200 and pay by credit card, or send a cheque and your name and address to cover the full cost to: Alison Maloney, Publications, Teagasc, Oak Park, Carlow.

EAAE best poster

Congratulations to Xavier Vollenweider, a Teagasc Walsh Fellow in Rural Economy based at the London School of Economics (LSE), whose paper, 'What is the impact of risk on inequality? Evidence from the Irish agricultural sector', jointly written with Dr Salvatore Di Falco (LSE) and Dr Cathal O'Donoghue, Head, Teagasc Rural Economy and Development Programme, won the prize as best poster of the 13th EAAE Congress. His oral paper on 'Risk Preferences of Irish Dairy Farmers' was also short-listed for best paper at the conference.

Padraig O'Kiely receives lifetime award

From left: Dr Fearga O'Kiely; Dr Aidan Conway, past-president of the Irish Grassland Association; Dr Padraig O'Kiely, Teagasc, Grange; and, Dr Padraig French, President, Irish Grassland Association.

At the recent Irish Grassland Association beef conference and farm walk, the Irish Grassland Association Lifetime Merit Award for 2011 was awarded to Dr Padraig O'Kiely, Teagasc, Grange. The award is presented to individuals, chosen by the council of the Irish Grassland Association, who have contributed significantly to progressive work within grassland technology and grassland farming.

Driving rural development

At the National Rural Development Conference were (from left): Dr Maeve Henchion, Teagasc; Tommy Cooke, ICMSA; Dr Edgar Morgenroth, ESRI; and, Dr Cathal O'Donoghue, Teagasc.

Speaking at the National Rural Development conference in Athlone on October 19, Teagasc Director Professor Gerry Boyle said: "Growing primary production will help to create additional employment in existing food industries and create new jobs as new food businesses develop". Highlighting the importance of the artisan and speciality food sector, Dr Cathal O'Donoghue, Teagasc, said: "There are 400 speciality food companies employing over 3,000 people with an estimated value of €475 million".

Award for Walsh Fellow

Sinead Murphy, a Walsh Fellow at NUI Galway, works with the Agricultural Catchments Programme. Sinead recently presented her research at the DiPCon meeting in Rotorua, New Zealand. The presentation, 'Investigation of bacterial pathogen sources and transfer hydrodynamics in rural catchments' was awarded the Best Oral Presentation for a Young Water Professional in a joint session on 'Diffuse Microbial Pollution and Health-Related Water Microbiology'.

What's for Lunch?

What's for Lunch? was a showcase event organised by the EU in September to highlight the results of projects in the area of food and bacterial traceability. Details and videos of the event can be found at http://webcast.ec.europa.eu/eutv/ portal/archive.html?viewConference=12928.

Pictured at 'What's for Lunch' were (from left): Dr Geraldine Duffy, Head of the Teagasc Food Safety Department; presenter Dr Kaye Burgess, Teagasc Food Safety Department; Mairead McGuinness MEP; and, Kieran Jordan, Teagasc Food Safety Department.

T News

UCD and Teagasc sign partnership agreement

Pictured at the signing of the Memorandum of Agreement to establish 'The National Agricultural Research, Education and Innovation Partnership' are (from left): Director of Teagasc, Professor Gerry Boyle; President of UCD, Dr Hugh Brady; and Michael Berkery, Chairman of the UCD Teagasc Joint Working Group. (Pic: Jason Clarke Photography.)

UCD and Teagasc have signed a Memorandum of Agreement to establish 'The National Agricultural Research, Education and Innovation Partnership'. The Partnership will enhance the scientific and technical leadership of UCD and Teagasc in order to underpin the international competitiveness, growth and sustainable development of the agricultural sector. It will provide world-class education for agricultural students and deliver excellent basic and applied research programmes in key areas of relevance to the development of Irish agriculture.

NetGrow e-zine launched

A new e-zine has been launched that will provide the food industry, academia, policymakers and other relevant stakeholders with up-to-date information on innovation and network-related news, activities and events, at both European and international level. It is produced as part of an EU-funded project, known as NetGrow, which aims to enhance the innovativeness and business performance of food companies, and especially food SMEs. The project aims to develop practical tools that will help both companies and support agencies to improve the learning and innovation that happens in networks.
To subscribe, see:
http://teagasc-netgrow.cmail2.com/t/ViewEmail/y/39BCF636E2AAF779/FC103C920EE43AAB05263A35EB2CBB57.

New Teagasc sheep programme

Teagasc has launched a new Sheep Research and Knowledge Transfer Programme in Teagasc, Mellows Campus, Athenry, Co. Galway. The new programme will support the 30,000 Irish sheep farmers who keep a national breeding flock of 2.5 million ewes, and will assist them to increase efficiency at farm level, increase production nationally, and increase the level of Irish exports of sheep meat. The *Food Harvest 2020* report has set a target of increasing the output of the sheep sector by 20%.

Teagasc article on most read list

A paper co-authored by Teagasc researchers Eimear Gallagher and Maria Hayes – 'Heart Health Peptides from Macroalgae and Their Potential Use in Functional Food' – has been listed as one of the top ten most read articles in the prestigious *Journal of Agricultural and Food Chemistry*.

CAP reform and sustainability

Speaking at the annual conference of the Agricultural Economics Society of Ireland (AESI) in November, Prof. Alan Matthews from Trinity College Dublin discussed issues raised for Irish agriculture as a result of the legislative proposals to amend existing CAP regulations in the post 2013 period. Dr Fiona Thorne, Teagasc, speaking about the economic sustainability of the current model of Irish dairy farming, said that the competitive position of the Irish dairy sector at farm level remains favourable in cash cost terms. However, when additional costs are factored in to cover the operator's owned land, labour and capital, the Irish dairy sector's performance is less impressive.
Highlighting the impact of the recession on farm households in Ireland, Head of the Rural Economy and Development programme in Teagasc Dr Cathal O'Donoghue said: "Despite the relatively buoyant commodity prices prevalent in 2011, farm households have faced a number of income shocks within the economic crisis in Ireland since 2008. In particular, off-farm employment rates are now returning to 1999 levels, and reductions in subsidies such as REPS and changes in taxation are all impacting on welfare at household level".

Enzyme technology may overcome cheese 'problems'

Enzyme technology may be one way of producing cheeses that are more natural, contain fewer additives, and are E-number and GM free, according to a joint symposium in Cork organised by UCC and Teagasc. Some 185 delegates attended from at home and abroad to hear a number of speakers, including Dr Tim Coolbear from the Fonterra Research Centre in New Zealand, who argued the case for enzyme technology in cheese production in the future. Other speakers included Professor Bart Weimer, who spoke on lactic acid bacteria in cheese, and Dr John Hannon of Teagasc and Dr Anne Thierry from INRA (France), who outlined research on cheese flavour.

Funding award

Dr Chris Creevy of Teagasc Grange, in conjunction with Dr Sinead Leahy of AgResearch, has made a successful application for a GRASS travel grant and will travel to New Zealand for two months in 2012 with the group involved in the metagenomic analysis of rumen microbes in Palmerston North. In addition, the proposal from AgResearch to the Joint Genome Institute (JGI) to sequence 1,000 rumen microbial genomes ('The Hungate 1000') has been approved and Teagasc will be involved in the project from the perspective of possible data contribution and data analysis.

National Tillage Crops Forum

A packed conference hall of growers and industry participants listened to an afternoon of technical updates and prospects for markets in 2012 at the National Tillage Forum on September 7, in Newbridge, Co. Kildare. Raluca Rusu from the DG Agriculture described EU attempts to reduce volatility in grain markets by providing measures to improve transparency in traded grain and also to provide more timely and detailed market information to help growers make more informed decisions. Eimear Gallaher, Teagasc Food Research, Ashtown, told the forum that the non-flour, non-bran component of barley, known as middlings, contains high levels of beta-glucans, which can be included in bread and have been shown to prevent hardening of arteries, reduce type 2 diabetes and lower cholesterol. Barry O'Reilly from variety testing in the Department of Agriculture gave an update on new varieties.

A panel of industry representatives shared their views on how the industry could add value to their grain output. Topics included malting barley, milling oats and grain storage options available to growers through merchants.

Probiotic research

A major collaboration between the Teagasc Food Research Centre and the Japanese company Suntory Wellness Limited on research into probiotics is commencing. This new collaboration is funded under an Enterprise Ireland Innovation Partnership scheme.

Dr Takayuki Izumo, a scientist from Suntory Wellness Limited, will work at the Teagasc Food Research Centre, Moorepark, for the next two years. He will work closely with Teagasc's Dr Catherine Stanton and scientists in the Alimentary Pharmabiotic Centre (APC) to characterise the health effects of the probiotic bacteria *Lactobacillus pentosus*. Ultimately, the project will investigate *Lactobacillus pentosus* strains as probiotics, and will evaluate the efficacy of both Japanese and Irish cultures for the development of credible and substantiated health claims.

British Grassland Society

Gareth Burns, Teagasc Walsh Fellow, Teagasc Grange, and affiliated with DARD at Crossnacreevy, Northern Ireland and Queen's University Belfast, received the award of best presentation of a paper at the British Grassland Society 10th research meeting in Belfast in September.

EUCARPIA 2011

DIRK REHEUL of the University of Gent, Belgium, reviews the proceedings of the 29th EUCARPIA Fodder Crops and Amenity Grasses Section Meeting, which took place in Dublin Castle in September.

EUCARPIA is the European Association for Research on Plant Breeding. With over 1,000 members, it is one of the largest scientific societies in the world dedicated to advancing scientific research in plant breeding. The society is organised into sections focusing on different crops and research areas, and these sections hold scientific conferences every two to three years. This year, one of the largest sections, the Fodder Crops and Amenity Grasses Section, held its 29th meeting in Dublin Castle. The conference was organised by staff from Teagasc's Crops, Environment and Land Use Research Programme, Oak Park, and the Department of Agriculture, Food and the Marine. Nearly 120 scientists from 21 countries, all working in the area of the genetics and breeding of forage species, attended the meeting.

The Minister for Agriculture, Food and the Marine, Simon Coveney, TD, opened the meeting. He welcomed the delegates and presented the Department's ambitious *Food Harvest 2020* plan. He outlined how the plan aims to put Ireland on the world map as a global leader in efficient grassland systems and grass-based food production, and as a substantial food exporter in the EU. The Minister believes that grassland scientists and breeders will play an important role in achieving these targets.

Professor Gerry Boyle, Director of Teagasc, welcomed EUCARPIA to Ireland 40 years after its previous meeting here. He outlined how Teagasc has changed over time and focused on its actual mission based on three pillars: research, education and extension. He outlined to delegates how transmitting new knowledge created by Teagasc researchers is considered to be a very important strategic action to achieve the goals of *Food Harvest 2020*: "To date, the Teagasc breeding programme has released 21 perennial ryegrass varieties of different ploidy and maturity levels, one tall fescue variety and eight white clover varieties". Looking to the future, Professor Boyle said: "We are now seeking to replicate our success in the bovine breeding arena by implementing biotechnology-based methods in our grass breeding programme over the next number of years".

Dr Beat Boller, Chairman of the Section, highlighted the mission of EUCARPIA "to promote scientific and technical collaboration in the field of plant breeding", and thanked the organisers for the excellent facilities in Dublin Castle. He presented the scientific programme of the meeting, at which breeding strategies was one of the main topics. Dr Boller asked the delegates to think about how new scientific knowledge and rapidly emerging developments can be incorporated efficiently in breeding programmes.

Role of grasslands in food security and climate change

In the first presentation of the scientific programme, Frank O'Mara, Director of Research at Teagasc, outlined the role of grasslands in food security and climate change. He elaborated on both the potential and the challenges of grassland ecosystems in terms of the conservation of soil quality, greenhouse gas emissions and the production of much needed protein to feed the world.

Genomics

During four full days, delegates were informed by oral presentations and posters on recent scientific advances regarding breeding strategies, breeding objectives and new tools in several grass and legume species. There was an important emphasis on genome analysis, genotyping and phenotyping, molecular marker technology and genomic selection. Some of the presentations focused on fundamental research while a minority emphasised how to apply these new techniques.

Several presentations and posters focused on the use of germplasm of grasses and legumes to install or improve the vegetation in different environmental conditions, particularly under conditions to be expected as a result of climate change. Roots of forage species are expected to become an important tool to enhance the carbon stock in soils or to prevent or limit flooding.

Higher sugar grass and digestibility

Other presentations and posters focused on breeding work to change the morphology and/or composition of different grass species and legumes. Earlier or ongoing breeding work resulted in higher sugar grass, improving the nutrient use efficiency in the grazing animal, the benefits clearly being greater under low to moderate nitrogen fertilisation. Research groups are trying to improve cell wall digestibility or to enhance "rumen escape protein" in order to increase animal performance, but also to mitigate nutrient losses and emissions. Enhancing the concentration of α-linolenic acid in grasses and clovers may result in healthier dairy products and/or meat owing to a higher concentration in ω-3 fatty acid and conjugated linoleic acid. Unravelling the diversity in branching in red clover and the tillering capacity in perennial ryegrass may lead to improved persistence.

Biotic and abiotic stresses

Breeding for biotic (pests and diseases) and abiotic (e.g., winter-hardiness, tolerance to drought and saline conditions) stresses is a permanent topic in all breeding work and germplasm characterisation. The results of the EUCARPIA multi-site rust evaluation (24 sites in 11 European countries) show that over a period of 11 years there is no evidence that crown rust resistance in individual *Lolium* cultivars was overcome by the pathogen. Quite a lot of work is conducted in *Festulolium*, the cross between *Festuca sp.* and *Lolium sp.* In a satellite meeting, the *Festulolium* working group presented their progress and checked for potential forms of collaboration.

Breeding

Breeding work in grasses and forages is focused on different forms of phenotypic selection followed by tests to quantify the breeding value of selected individuals. A large number of new techniques are evolving (or existing techniques continue to be improved) and they may change future breeding work in the short to long term. At the meeting, we heard how near infrared spectroscopy applications are becoming smarter, and enable substituting of laborious chemical analyses; how high-performance chemical analyses allow us to identify biochemical substances related to important traits in forages; and, how highly automated installations applying several image-based instruments are becoming extremely valuable tools in phenotyping large numbers of plants to give new insights into previously unknown physiological characteristics of plant growth.

Gene hunting

In nearly all aspects of breeding work and breeding research, 'gene hunting' is important. Gene mapping, the search for genetic markers linked to important traits and the search for QTLs (quantitative trait loci, influencing the expression of traits regulated by different genes) is the subject of the work of a large number of researchers and was the topic of many presentations and posters. The underpinning idea is that a better knowledge of the genes controlling key characteristics will enable us to make the breeding work more predictable. While a number of presentations focused on the fundamentals of the development of these new technologies, others showed clear and cost-effective application in breeding companies. Delegates heard that one does not always need the most complicated techniques to identify important genetic markers for breeding. An excellent illustration of this was given by breeder Heathcliffe Riday (United States Department of Agriculture, Agricultural Research Service), who outlined the application of genetic markers in the identification of paternity of seeds produced by cross pollinated crops (as most of the forage crops are), enabling a faster breeding progress or a better variety purity.

Genomic selection

On the other end of the complexity (and cost) scale, there were a series of presentations about advances in methodologies to apply genomic selection. The final goal of genomic selection is to determine the breeding value of individuals, not by testing their progenies, but by analysing their DNA. Molecular genetics combined with the analysis and processing of huge amounts of data, is necessary to achieve this goal. Despite the challenges, if successful, genomic selection may dramatically speed up the breeding process and substantially increase genetic gains.

Pictured at the opening of EUCARPIA 2011 are (from left): Professor Gerry Boyle, Director, Teagasc; Simon Coveney, TD, Minister for Agriculture, Food and the Marine; Dr Beat Boller, section chairman of EUCARPIA Fodder Crops and Amenity Grasses Section; Dr Timothy Hall, DG Research, European Commission; and, Drs Susanne Barth and Dan Milbourne, Teagasc Crops, Environment and Land Use Research Programme, Oak Park, Carlow.

Field trip

The mid-congress visit to Teagasc Crops, Environment and Land Use Research Programme, Teagasc Oak Park, Carlow, showed the excellent Irish breeding work and genetic research in perennial ryegrass, and white and red clover. Dedicated Teagasc advisers and researchers showed how technology transfer in practice allows efficient grass-based milk production during a visit to a progressive dairy farm.

Whatever their research domain, all delegates were supplied with useful information. Networking offered the opportunity to get involved in an extremely fast-changing world. Contacts between field breeders and researchers in the labs are a prerequisite for further progress in the improvement of forage species. The 29th EUCARPIA Fodder Crops and Amenity Grasses Section Meeting was, in this respect, most interesting and valuable. All delegates will remember the warm hospitality of the organisers of the Dublin meeting.

Molecular geneticists Dr Susanne Barth (chairperson of the organising committee) and Dr Dan Milbourne, Crops, Environment and Land Use Research Programme, Teagasc Oak Park, are leading the development of biotechnology-based tools for perennial ryegrass and white clover at Teagasc. Dr Barth said: "Our new initiative at Teagasc involves close collaboration between scientists from disciplines as diverse as biotechnology and grasslands management, which will maximise the relevance and utility of the research we are doing to Irish pasture-based production systems".

The proceedings of this conference will appear in a book published by Springer in 2012.

Professor Dirk Reheul, Professor in Plant Breeding, Gent University, is Chairman Elect of the EUCARPIA Fodder Crops and Amenity Grasses Section.
E-mail: susanne.barth@teagasc.ie.

Conserving farmland biodiversity

DAIRE Ó HUALLACHÁIN and JOHN FINN report on a recent farmland biodiversity conference.

The *Food Harvest 2020* report (DAFF, 2010) outlines a vision for the agri-food sector wherein the conservation of biodiversity is one of the priority environmental goals. Against this background, the Teagasc conference 'Conserving Farmland Biodiversity: Lessons Learned and Future Prospects' was attended by farmers, consultants, researchers and policy-makers. Here we report on some of the main issues that emerged from the conference.

Policy background and update

The conservation of biodiversity is a key environmental objective for the European Union and its Member States. In the first systematic assessment of the most threatened and diverse European habitats, protected habitats associated with agriculture (including priority habitats) were of 'poor' or 'bad' conservation status, and were of considerably worse status than other protected habitats. The EU target to halt biodiversity loss by 2010 has not been met, and the EU is strengthening its policy framework and commitment to halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as is possible. The updated Irish National Biodiversity Plan (DAHG, 2011) clearly highlights the importance of biodiversity conservation in the wider countryside (most of which is farmland), in addition to the protection of designated areas (and other targets).

In one of the keynote presentations at the conference, David Baldock (Institute for European Environmental Policy) highlighted that the provision of public goods (including biodiversity) was likely to be strengthened in the EU's post-2013 Common Agricultural Policy (CAP). Since then, Commission documents have indicated several proposals for 'greening' the CAP (note that these may change). In proposals for Pillar I of the CAP, 30% of the direct payments may be linked to ensuring that all farms deliver environmental and climate benefits through the retention of soil carbon and grassland habitats associated with permanent pasture (≥5 years), the delivery of water and habitat protection by the establishment of ecological focus areas and improvement of the resilience of soil and ecosystems through crop diversification. Those practises should take the form of simple, generalised, non-contractual and annual actions that go beyond cross compliance. Ecological focus areas (e.g., fallow land, landscape features, buffer strips and some afforested areas) are introduced for the first time, and the proposals indicate that these would comprise 7% of the eligible hectares (excluding areas under permanent grassland).

In Pillar 2, an important policy instrument for Irish farmers is the agri-environment measure. A recent European Court of Auditors assessment of the design and management of EU agri-environment schemes highlighted a number of deficiencies in their design and management, including a lack of specific objectives, unclear justification, and a poor ability to assess whether the schemes are achieving their intended environmental objectives. The Court of Auditors strongly emphasised the need for increased targeting of measures, and for clearer distinctions between 'deep and narrow' and 'broad and shallow' measures. In the past, the Court's recommendations have resulted in major changes to cross-compliance and verifiability, and it is likely that these recent recommendations will appear in the implementation of post-2013 agri-environment schemes.

High nature value farming systems

High nature value (HNV) farming systems are largely dependent on vegetation composed of naturally occurring wild plant species for grazing or fodder production, and are among the headline environmental indicators of the Rural Development Programme (RDP) of the CAP. EU Member States are supposed to identify the spatial distribution of such areas and target agri-environmental payments. Although Natura 2000 (EU-wide network of nature protection areas) often includes HNV farming systems, much of it lies outside of designated areas and, as such, is afforded little protection. A clear knowledge gap highlighted at the conference is the identification of HNV farmland in the wider countryside, and the definition of appropriate management prescriptions to ensure favourable conservation status. Several presentations at the conference addressed HNV farmland. The EU/National Parks and Wildlife Service-funded Burren Farming for Conservation Programme (www.burrenlife.com) demonstrated that with tailored and tested prescriptions, coupled with the close co-operation of Government departments and the farming community, real advances can be made in the area of biodiversity protection and enhancement. The Science Foundation Ireland-funded BioUP project in the Iveragh Peninsula highlighted the dependency of farm incomes on CAP payments, and the threat of land abandonment.

Farmland birds

Farmland birds are another headline indicator for the RDP. Agricultural intensification is most likely responsible for the continued declines in many farmland bird species. Speaking at the conference, Alex Copland (Birdwatch Ireland) concluded that REPS has failed to halt the declines in farmland bird populations. The grey partridge (*Perdix perdix*) is a farmland bird species that has declined to one remaining naturally occurring population in the Republic of Ireland. Nick Sotherton (Game and Wildlife Conservation Trust) and Kieran Buckley (National Parks and Wildlife Service) highlighted the importance of habitat creation, predator control and subsequent appropriate habitat management in halting the decline in partridge numbers. Measures that are designed to protect and enhance grey partridge numbers could potentially

Far left: Low intensity extensive farming systems allow biodiversity to flourish and can result in HNV-type farmland.

Middle: The development of effective supplementary measures is vital to protect water quality and biodiversity.

Left: The grey partridge has declined to one remaining naturally occurring population in the Republic of Ireland. Measures designed to protect and enhance grey partridge numbers could benefit a wide range of farmland biodiversity.

benefit a wide range of farmland biodiversity, including birds, small mammals and invertebrates. The conference heard that if future agri-environment schemes are to effectively conserve farmland bird populations, then more focused objectives are required. These schemes must allow species targeting, both geographically within Ireland and also for specific habitats. This is true not only for farmland bird populations, but for farmland biodiversity in general.

Other biodiversity issues

Here we give a short outline of some other priority issues that emerged at the conference. The freshwater pearl mussel (*Margaritifera margaritifera*) and the Nore freshwater pearl mussel (*Margaritifera durrovensis*) are endangered throughout their range, and are protected under both the Habitats Directive and the Water Framework Directive. In a keynote address, Evelyn Moorkens commented that it is impossible to save every mussel in the 27 sub-basins throughout Ireland and, therefore, a strategic approach is required to prioritise conservation efforts where returns are likely to be greatest. An evidence-based prioritisation of catchments, based on objective, recommended focusing conservation efforts on the top eight catchments, which contain 92% of the national mussel population. Conservation of these eight catchments would be more likely to provide the best return for investment in terms of current mussel numbers protected, and the ability to return populations to sustainable reproduction levels.

Donnacha Doody (Agri-Food and Bioscience Institute) said that the development of effective supplementary measures was vital to protecting water quality and biodiversity in high status water bodies (Lough Melvin, in this case). He stressed that the participation of farmers and other stakeholders is central to the successful development of measures that are site-specific, cost effective, environmentally efficient, and that can be successfully implemented within existing farming systems.

Conclusions

Several discussions highlighted the variety of objectives that exist for farmland biodiversity, and the distinctions between 'broad and shallow' and 'deep and narrow' approaches to conservation. There was also some detailed discussion about the trade-offs that occur between benefits from spatial targeting and locally implemented measures, and the increased administrative costs associated with their design and monitoring. Several delegates and presenters directly addressed a specific example of counteracting EU policies in relation to rules on 'eligible area' under the Single Payment Scheme. Contributors stated that current prescriptions were too restrictive and inflexible, and could result in the reduction of payments to farmers who managed habitats in a way that was beneficial to biodiversity. In the Burren, the mosaic of grassland and limestone pavement that invokes the Natura 2000 designation is also problematic for new rules for the Single Payment Scheme. Burren farmers are facing reductions of over one-third, and such areas are not eligible for the Burren Farming for Conservation Programme.

Looking to the future, representatives from the National Parks and Wildlife Service identified the following issues as national priorities for biodiversity in the coming years:

- management of freshwater systems;
- conservation of the freshwater pearl mussel;
- management of overgrazed (and undergrazed) uplands;
- conservation of birds in serious decline, including farmland bird species, e.g., corncrake, breeding waders, partridge, barn owl, etc.; and,
- protection and restoration of bogs and other wetlands.

While the attainment of biodiversity objectives remains a legislative priority, there is also a strong need to identify the least-cost ways of achieving objectives. With limited budgets, the need for specific objectives, quantitative targets, spatial targeting and proven cost-effectiveness of biodiversity conservation actions will increase.

The proceedings of the conference and all oral presentations are available at http://www.teagasc.ie/publications/2011/996/.

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Nutrient loads from agri-catchments: environmental risk or economic write-off?

Teagasc's Agricultural Catchments Programme is based on a partnership with farmers and other stakeholders. The Programme aims to support productive agriculture and the protection of water quality.

Nutrients such as phosphorus and nitrogen can run-off and drain from agricultural land and can pose risks to surface and groundwater quality through the eutrophication process. The Nitrates Directive National Action Programme (NAP) is designed to reduce these nutrient exports. Water quality regulations stipulate nutrient concentration thresholds for rivers and groundwater but don't set targets for export rates. It is now accepted that these nutrient exports to waterways from the farming system may also be considered an economic loss and that reducing nutrient losses presents win-win opportunities – but this raises new questions about how high the bar should be raised. In other words: what level of nutrient loss is acceptable?

Teagasc Agricultural Catchments Programme

The Teagasc Agricultural Catchments Programme (ACP) is an ongoing research and evaluation project to support Ireland's NAP and derogation (Phase 1 2008-2011; Phase 2 2012 to 2015). Six agricultural catchments have been intensively instrumented and high resolution datasets are being analysed in a sophisticated database management system (Fealy *et al.*, 2010). Part of this work is to look closely at the exports of nutrients leaving catchments, as regulations within the NAP are specifically designed to mitigate this loss. For example, the NAP limits the timing and magnitude of slurry and fertiliser applications, especially during periods when these can be 'washed off' the land by rainfall. The regulations are among the main mitigation measures to combat diffuse pollution from agriculture under the Water Framework Directive. The ACP uses a nutrient transfer continuum concept as an experimental design framework for evaluation of the effectiveness of the NAP (Wall *et al.*, 2011). This includes audits of nutrient sources at field and farm level; focused studies on subsurface and surface pathways; and, audits on delivery of nutrients to mainly river systems. There is an implicit assumption that nutrient source use and storage is compliant with the regulations and that excesses of, for example, phosphorus in soils and nitrate in groundwater are due to a legacy of previous management and will decline according to physiographic lag times (Schulte *et al.*, 2010; Fenton *et al.*, 2011). In rivers, ACP uses a novel approach for monitoring both phosphorus and nitrate (as total oxidised nitrogen – TON) on a sub-hourly basis and synchronous with measurements of river flow. This continuous and high resolution data coverage captures the highly variable temporal dynamics of nutrient delivery to rivers from agricultural land. Complete annual time series of data provide nutrient export rates for specific suites of land use and catchments and seasonal data for periods associated with, for example, the closed spreading periods.

Annual losses

An example for the April 1, 2010 to March 31, 2011 period is shown for four catchments in **Table 1**. The data show annual rain, river flow, and two fractions of phosphorus and nitrate. Also shown is the percentage of each measured parameter during the closed slurry spreading period (chemical fertiliser and farmyard manure closed periods are slightly longer and shorter, respectively). Examples of the time series data are shown for one of the arable catchments in **Figure 1** and how these losses evolve over an annual cycle.

Reducing nutrient load

Two issues emerge from these data and are being investigated as part of the ongoing experiment. The first is related to the mode of nutrient transfer and related nutrient standards in rivers. The NAP is concerned with reducing the nutrient load exported from land by constraining both source and transport potential and the data for this hydrological year show total phosphorus exports of between 0.175kg/ha/yr and 0.784kg/ha/yr, and 8.900kg/ha/yr to 28.820kg/ha/yr for nitrate-nitrogen. However, no river export standards exist in any of the EU surface water regulations and exports are generally poorly related to the river concentration standards set by authorities for Water Framework Directive reporting. Despite exports being a difficult metric to set owing to the influences of varying annual climatic variation, (i.e., more storms means more exports) they are important for the trophic status of receiving standing waters such as lakes (for phosphorus) and estuaries (for nitrogen), and important for the farming industry to know what are environmentally acceptable limits. In terms of environmental risk, an exploration of acceptable phosphorus export limits for Irish lakes will be presented in a future issue of *TResearch*. As these exported loads may also represent an economic loss, it is important to know what exactly is going down the

Table 1: Annual and closed period hydrology and nutrient exports from four experimental agricultural catchments. TP is total phosphorus; TRP is total reactive phosphorus; TON is total oxidised nitrogen.

	Grassland A	Grassland B	Arable A	Arable B
Catchment area (ha)	758	1207	1116	948
Rain (mm)	1019	939	857	791
During closed season (%)	29	31	25	25
Discharge (mm)	510	413	491	393
During closed season (%)	32	47	36	42
TP load (kg/ha/yr)	0.541	0.701	0.175	0.784
During closed season (%)	40	48	29	37
TRP (kg/ha/yr)	0.317	0.354	0.101	0.350
During closed season (%)	41	50	33	39
TON, kg ha^{-1} yr^{-1}	27.356	8.900	28.820	19.645
During closed season (%)	32	47	36	45

river and how nutrients can be better kept and utilised on the land in the future. In **Figure 1**, for example (at current prices), the cumulative export of phosphorus in the river system equated to an approximate equivalent of €2.30ha/yr and for nitrate-nitrogen approximately €21.60ha/yr from this arable catchment. However, the economics of nutrient loss from agricultural land is likely to go further than the balance sheets of individual farms as eutrophication of water resources is likely to have long-term financial consequences in terms of management and mitigation. Minimising external economic as well as ecological impacts from eutrophication are prime motives of the Water Framework Directive.

Closed period nutrient exports

The second issue is related to closed period nutrient exports. The ACP assumes compliance in terms of storage capacity and management, and these conditions are being studied on an ongoing basis. The exports of phosphorus and nitrogen during these periods, therefore, represent residual losses owing to diffuse events from soil and groundwater stores. For slurry spreading, the closed periods represent approximately 25% of annual rainfall. The nutrient losses observed during the closed period in this dataset were all greater than 25% and up to 48% of the annual export of total phosphorus and 50% of nitrate, and due mainly to cumulative losses during run-off events (fast overland flow for phosphorus and storm recession flow for nitrate). It appears from these early data and analyses (subject to peer review) that the current closed period remains a time of significant risk of nutrient loss in some catchments.

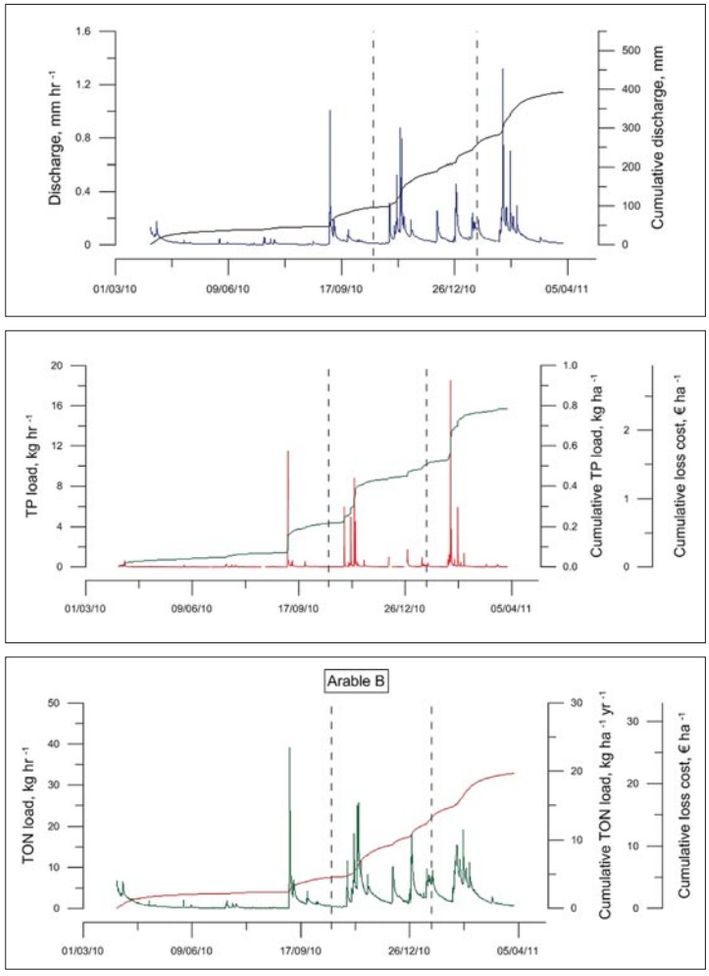

FIGURE 1: Time series of high resolution (hourly) data of river flow, total phosphorus and nitrate (as TON) exports in the 'Arable B' catchment (948ha) over one year. Dashed vertical lines indicate start and end of the closed slurry spreading period (October 15 to January 15 in this catchment).

Benefits to industry

With closed periods in place, lag times between management change (such as matching nutrient application to crop requirement) and medium- to long-term reductions in field nutrient sources (such as soil test phosphorus levels) will be important determinants of future nutrient losses during winter and also important in gauging the economic benefits of nutrient use or retention efficiencies.

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T Food

Teagasc recently hosted a 'Package Your Way to New Markets' seminar at its Training & Conference Centre in Ashtown, Dublin.

Teagasc, Enterprise Ireland and Bord Bia recently came together to provide food businesses with information on the trends in food packaging and an opportunity to network with researchers from Teagasc and other third-level institutions, and to explore innovative packaging ideas. The three agencies worked together to combine their complementary expertise in the areas of technical advice and innovation, business development, branding and marketing. A number of eminent speakers in these areas addressed 78 participants from 55 organisations on such topics as branding, marketing, innovation, packaging formats, trends, the impact of food law and sustainability. The aim was to stimulate interest in innovative approaches to packaging that could be followed up with researchers from around the country and the three agencies.

Functions of food packaging

Food packaging must be fit for purpose and has many functions. It forms a physical barrier and protects against shock, vibration, compression and temperature fluctuation. It also protects and preserves foodstuffs from the effects of oxygen, water vapour, dust and other contaminants. It functions as a container for liquid or small objects. It acts as a means of communication with the consumer and can provide information on transportation, storage, preparation, use, recycling, or disposal, as well as a means of marketing the product and encouraging potential buyers. It may also have security functions such as pilferage prevention (tamper resistance, deterrence and indication). Providing a means of convenient handling, display, sale, opening, dispensing, re-closing, use, and re-use has become an increasingly important function of packaging, as has its role in portion control, e.g., by providing a means of single serving or single dosage. To source and design packaging that can perform all of these functions is a challenge for industry.

Branding and marketing

Pat Kinsley of New World Associates spoke about branding and what a successful brand means, but also warned businesses against trying to sell consumers something that cannot be delivered on. A successful brand tells a story, is trusted, makes or fulfils a promise, is consistent and authentic, is rarely aimed at everyone, is engaging and is often subtle – it doesn't appeal to our logic but more often to our senses. And if you think about some iconic brand images that we all know, that's exactly what they do!

Sheila Gilroy-Collins of Donegal Creameries Plc. provided a case study about the successful Rumblers brand and the 'Organic for Us' story. She gave some interesting insights into aspects of market research, successful product launch and brand, using competitions as a marketing tool, the importance of matching the medium to your target audience, and the pros and cons of using social media. She also advised food businesses to have a shared vision and goal, and to understand their measurable competitive advantage. Both Pat and Sheila emphasised the importance of understanding your customers and your consumers! Remember, for food businesses the customer is often the retailer, while your packaging and brand need to appeal to the final consumer. Their combined needs will place demands on the design and functions required of the food packaging.

Consumer convenience, sustainability and extended shelf life are all driving innovation and changes in packaging formats.

Market trends

Food packaging must meet the needs of today's consumer. Jonathan Fowle of PIRA International highlighted some of the demographics and lifestyle factors that should be considered when making packaging choices. Portion control, direct consumption, fast heating in microwaves, and senior-friendly/easy-to-open packaging are all in focus. Other aspects that are influencing consumer choices are value for money, indulgence, health and ethical considerations. High growth packaging formats include plastic tubs/trays/jars/pots, stand-up pouches, shelf-ready cardboard, shrink sleeves and collation shrink. There is increased growth in the use of plastics based on cost and performance. Replacing rigid containers with more flexible formats has supply chain benefits. Consumer convenience, sustainability and extended shelf life are all driving innovation and changes in packaging formats. Food waste is a huge problem in the Western world, and is much worse in developing countries where >50% of food can be wasted due to lack of retail infrastructure. Just one to two extra days for very short shelf life chilled products can realise substantial savings and reduction in waste. The trend towards more prepared fruit and vegetables to be pre-packed is continuing in the Western world, facilitated by improved packaging systems technology. There are opportunities for food businesses and researchers in relation to active and intelligent packaging features to extend shelf life.

Sustainability

Both customer demand and legislative requirements are driving the need for packaging to be more sustainable. John Curran of the Musgrave Group and Colm Munnelly of Repak highlighted a range of issues around sustainable packaging. The aim of sustainable packaging must be to optimise the environmental efficiency of all packaging while balancing sustainability, fitness for purpose and cost. The challenge for businesses is to remove, reduce, replace, recycle or reuse packaging where possible. There is also the possibility of recovering energy, for example by burning plastics to produce heat. Food businesses should eliminate unnecessary packaging or reduce it to the lightest weight possible while still maintaining function. More eco-efficient materials can be used to replace more traditional materials. It is important to select packaging materials that fit national recycling schemes; aluminium, steel and glass are all conducive to recycling. Consideration should also be given to the potential for reusable or returnable packaging formats. There is often potential for this in relation to secondary or transport packaging. Packaging can be said to be sustainable where it is sourced responsibly, designed effectively, safe through its life cycle, meets the expectations of performance and cost, is made from sustainable materials using renewable energy, and can be efficiently recycled.

Challenges posed by food law

Under EU food law packaging must not endanger the consumer or cause unacceptable changes in food composition or organoleptic characteristics. Labelling should allow the consumer to make informed choices and must not mislead. Recent food recalls have increased attention on food packaging in terms of the risk of migration of chemicals into the foodstuff. Chemicals from the primary or secondary packaging, and even the printing ink, have been found in food, so food businesses must ensure that all packaging materials are suitable for their intended use. With the increased popularity of plastics it's important that the material supplier can supply the required declaration of compliance.
New labelling legislation aims to enable consumers to make balanced and healthier dietary choices; it introduces a mandatory nutrition declaration

Brand and packaging design are investments in a product, and innovation in packaging can open doors and create new markets for Irish foods. (Image courtesy of Donegal Creameries Plc.)

(previously voluntary) and requires information to be accurate, clear and easy to understand. Compulsory country of origin labelling has been extended to other fresh meats in addition to beef. There are opportunities in relation to labelling, with permitted nutrition claims, protections for certain geographical indications and traditional specialities and organics under EU law. Labelling requirements are extensive, with many specific requirements and a number of exemptions, making it advisable for food businesses to pay close attention to the legislation or to seek expert advice if necessary.

Support for industry

A number of the speakers advised businesses to get help and to use the support of the Government agencies. There are industry supports available from Bord Bia, including their Brand Forum, innovation support 'foresight4food' and marketing assistance programmes, while Enterprise Ireland can offer financial support for certain innovation and feasibility studies, a number of which provide opportunities for researchers in Teagasc and third-level institutions to work in partnership with industry on development projects. Enterprise Ireland also provides a range of non-financial business support services.
In conclusion, brand and packaging design should be seen as an investment, not a cost! Consumer convenience, sustainability and extended shelf life are all driving innovation and changes in packaging formats. An innovative approach to packaging design will open doors and create new markets for Irish foodstuffs.

Teagasc wishes to acknowledge the support received from both Enterprise Ireland and Bord Bia for this event.

For more information on the Food Industry Development Department at Teagasc, visit http://www.teagasc.ie/food/research/fid/index.asp.
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The tender touch

The tenderbound© system requires a hot-boning process.

A review of carcass treatments utilised to enhance beef quality, including carcass hanging and hot-boning, was presented as part of a paper by DECLAN TROY to a conference in Sao Paulo, Brazil, recently.

A thorough understanding of the factors which influence meat eating quality is imperative in order to produce a product consistently in line with consumers' expectations. Furthermore this understanding is necessary in order to enable the meat industry to implement appropriate interventions and controls to produce a consistent, high-quality product. There is a strong reliance by the industry on the research community to develop outputs which, based on good science, can enhance meat eating quality.

Consumer-focused research into meat eating quality has shown that tenderness is deemed most important. Providing consistently tender beef should be the key priority for the beef industry. While there have been many successful efforts at improving the tenderness of beef, research has shown that an unacceptable level of variability still remains in beef tenderness.

There are many controls that can be introduced into the beef processing line in order to alleviate meat tenderness inconsistencies such as hanging the carcass by its aitch bone, electrically stimulating muscles and preventing muscles from shortening. This paper concisely reviews the methods of carcass hanging and how such methods can be utilised in the industry to produce tender beef consistently.

Post-slaughter factors

Post-slaughter factors have a higher influence on meat eating quality because the main determinants of meat tenderness are the extent of proteolysis on key structural proteins and the degree of shortening of the muscle fibres. (A third factor, the connective tissue component, is often referred to as 'background toughness'. It is little affected by post-slaughter events and its contribution to toughness is linked to the age of an animal and/or muscle type.)

Both these events (proteolysis and shortening) take place at varying rates and extents during the post-mortem period. The most likely causative agents responsible for the breakdown of key structural proteins in post-mortem tenderisation are enzymes, namely calpains, even though their precise mode of action is unclear. There is strong evidence that the proteins of the cyto-skeletal network such as titin, nebulin and desmin, are degraded by calpains during the tenderisation process. Furthermore it is now established that ageing beef beyond 10-12 days at 0-2°C does not contribute to any greater degree of breakdown of structural myofibrillar proteins nor detectable increase in eating quality. It is well known that the shorter the muscle fibres the tougher the meat. This is because the contraction allows the z-discs of the myofibril to be nearer each other, thereby increasing the density of filaments. This occurs during the normal onset of rigor. However, when early post-mortem variables of pH, temperature and time interact in such a manner as to induce cold-shortening (sarcomere lengths <1.7 microns), extreme toughness is experienced. Pre-rigor muscle shortens on exposure to temperatures below about 10°C. The faster the temperature decline the slower the rate of glycolysis and therefore the greater the degree of shortening. Cold-shortening occurs as calcium is uncontrollably released into the sarcoplasm, which in turn is due to the decrease in temperature and pH resulting in reduced ability of the sarcoplasmic reticulum and mitochondria to retain calcium.

The increase in concentration of free calcium in the presence of sufficient ATP results in greater shortening of the sarcomeres. Shortening causes the thick filaments to penetrate the z-discs and may interact with actin filaments in adjacent sarcomeres. This results in the extreme cases of a continuum of myosin throughout. This dense structure is responsible for the increased toughness experienced by consumers of cold-shortened beef.

In relation to beef carcasses it follows that if pH, temperature and time post-mortem (i.e., the biochemical dynamics) of the early post-mortem period are critical in determining the tenderness/toughness of meat, then meat throughout a carcass will experience a variety of biochemical profiles resulting in meat of highly variable eating quality. The rate of pH fall varies from animal to animal and the temperature varies considerably throughout a chill, a carcass and a muscle, and hence their interaction is highly variable.

Meat science has contributed to providing scientific data that has been employed effectively by the meat industry to reduce the risk of cold-shortening. From understanding of the early post-mortem period, specific recommendations have been implemented by meat processors.

Carcass suspension methods

Methods to reduce the degree of cold-shortening or increase the degree of stretching of sarcomeres by altering the normal hanging method of carcasses are becoming more commonly used by the industry. Various methods of hanging carcasses have been tried as an alternative to the conventional Achilles tendon method. Among the different hanging techniques developed to improve meat tenderness are tenderstretch, tendercut, and a forequarter hanging method. By far the most popular of these techniques in use is the 'tenderstretch' method. For this technique the hanging position is switched from the Achilles tendon to the aitch (hip) bone, thereby allowing the hind legs to hang freely. Tenderstretch induces a stretching effect on key hindquarter muscles, preventing the sarcomeres from

shortening and in some cases actually stretching the distances between z-lines reducing the density of overlap between the filaments. It was found that sarcomere lengths increased by 15%, 30%, 33% and 30% on average from tenderstretch suspended carcasses of *m. longissimus dorsi*, *semimembranous*, *biceps femoris* and the *gluteus medius,* respectively. Similarly, sensory analysis showed that panellists consistently rated all muscles from pelvic suspended carcasses as more tender (average 20%). In another study, less cold-shortening occurred in steaks from conventionally hung compared to tenderstretch suspension carcasses in those carcasses chilled faster. The *m. psoas major* or fillet has been found to be slightly toughened in pelvic suspended carcasses because of its particular position in the carcass.

Pre-slaughter factors do not impinge on eating quality to a major extent within the normal production systems of Northern Europe, unlike other areas where* bos indicus*-type cattle are prevalent.

In Ireland and the UK, pelvic suspension forms part of numerous retailer specifications, often in combination with a slow-chilling regime or in combination with electrical stimulation. The industry cites some drawbacks, however, including the requirement for more chiller space, demands for greater labour input and the distortion in shape of some muscles.

Researchers at Virginia Polytechnic Institute and State University have examined strategic pre-rigor cutting of the backbone to improve beef tenderness. This procedure is referred to as tendercut and requires an additional input of making cuts in the skeleton of the pre-rigor carcass shortly after slaughter while maintaining the Achilles tendon suspension. The weight of the carcass below the points of cutting stretches many of the major loin and round muscles. As with tenderstretch, the tendercut method does not benefit all muscles. It was reported that the use of the tendercut technique resulted in increased tenderness in some muscles with decreased tenderness in others. A report from Australia suggests that it is not as effective in increasing tenderness as the tenderstretch method. This technique has not been widely adapted by the industry. A more recent method was examined in Brazil. It is the effect of forequarter hanging on the *longissimus* and *biceps femoris* muscles. Hanging by the forequarter caused a significant improvement in tenderness of the *longissimus* muscles without any detrimental effect on the *biceps femoris*. This method has not been fully characterised up to now.

Tenderbound© system

A novel method to improve the eating quality of meat by reducing the degree of contraction in hot-boned beef is in the process of being developed for industry use at Teagasc Food Research Centre, Ashtown. As discussed earlier, a consistent optimum window of pH and temperature as a function of post-mortem time is very difficult to achieve given that the chilling rate, muscle location, level of fat cover, and animal-to-animal variation in metabolism, among other factors, are different. The tenderbound© system overcomes these difficulties. Hot-boning provides a significant advantage in that it enables individual muscles to be processed in a specific tailored fashion. The advantages and disadvantages of hot-boning are well known. Hot-boning requires the major commercial cuts or muscles to be excised within 90 minutes of slaughter and it thereby reduces weight loss during chilling, requires less chiller space, consumes less energy, lowers labour input and increases turnover in productivity. Its major drawbacks are that it needs precise synchronisation of slaughter, boning and processing activities, very strict hygiene control and induces toughness through greater ability of muscle fibres to contract in the absence of skeletal restraint resulting in cold shortening. Hot-boning in combination with a pre-rigor restraint technique using elasticated film constitutes the tenderbound© system.

The Pi-Vac Elasto-Pack system involves stretching tubes of elastic film to the inside walls of the packaging chamber; after the muscle is inserted into the chamber, pressure is released and the elastic film returns to its original dimensions. The elastic film then hinders the diametrical expansion of the muscle, which restricts muscle contraction. Hot-boned meat packed in Pi-Vac can be chilled much more rapidly while keeping the beef tender and of consistent quality. Hot-boned muscle without any restraint had higher shear force values (force required to shear through meat) after 14 days' ageing compared to muscle packed in Pi-Vac (72N and 40N, respectively). The sarcomere length, a measure of muscle extension or stretch, was increased considerably by use of the tenderbound© method (1.7µm) while the sarcomere length for hot-boned muscle without restraint was 1.3µm. The pre-rigor meat forms into the shape of its constraining pack and is not distorted. Using this system variability of tenderness is reduced as individual muscles can be treated optimally. Drip loss is reduced by packing early post mortem, thereby improving flavour and succulence. Bacterial growth can be reduced and shelf life improved because of the ability to chill at lower temperatures. Other potential benefits may include increased yield, reduced energy costs, quicker turnover of unit product in meat plant, and savings in labour and transport costs, although these have yet to be verified at industry level.

Conclusions

In order to produce beef with consistently high eating quality, post-mortem parameters must be taken into account. The two main strategic approaches are: to enhance the degree of proteolytic breakdown of cyto-skeletal proteins; and, to decrease the degree of shortening of sarcomeres. Ensuring a high degree of proteolysis can be approached in a number of ways, but as long as the beef carcass or muscle is aged for at least 10 to 12 days, almost all degradation relevant to the tenderisation process is complete. Reducing contraction can be easily carried out by aitch bone hanging or by the tenderbound© process. Pre-slaughter factors do not impinge on eating quality to a major extent within the normal production systems of Northern Europe, unlike other areas where *bos indicus*-type cattle are prevalent. The beef industry has the necessary knowledge to avoid producing tough beef but needs to implement more rigorous practices to do so.

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Protein aggregation in dairy food structures

Image courtesy Bord Bia.

Manipulating the degree of casein aggregation is critical in affecting the functional properties of cheese such as shreddability, sliceability and cooking behaviour.

The importance of protein aggregation in the architecture of dairy protein-based food structures is outlined by TIM GUINEE and ANDRÉ BRODKORB.

Protein – in particular casein – is a central structural component of many dairy-based foods, most notably yoghurts and cheeses, but it is also used as an ingredient in many formulated foods where casein ingredients contribute to water binding, emulsification, structure and texture. Careful control of the degree of casein aggregation during manufacture is a central tenet in engineering the desired quality characteristics (e.g., texture, mouthfeel, sensory properties, functionality) of these foods and ingredients. In contrast, uncontrolled aggregation is the basis of defects in products, e.g., gelation of UHT milks, protein flocculation/precipitation in beverages, graininess and non-viscous consistency in fresh cheeses and yoghurt-style products, and mealiness and seaminess in hard cheeses.

Proteins in milk

There are two main categories of proteins in bovine milk, namely caseins and whey proteins, at about 2.6 and 0.65%, respectively. Whey proteins occur as macromolecular solutes that are soluble in the serum or aqueous phase (solvent) of the milk. Caseins in milk are in the form of spherical-shaped colloidal particles (typically 200nm in diameter), known as micelles, dispersed in the serum phase. The micelles comprise casein (20%), insoluble calcium and phosphate (2.0%), and internal solvent (78%), which can be assumed to be compositionally similar to the serum in which they are dispersed. The individual casein molecules (α_s-, β-, κ-) contain charged amino acid residues (such as glutamate, aspartate, lysine) interspersed with hydrophobic domains, enabling them to cross-link and aggregate within the micelle by calcium-, calcium phosphate- and hydrophobic-mediated interactions. The κ-casein is predominantly situated at the surface of the micelle, where its C-terminal region protrudes into the serum phase in the form of hydrophilic hairs that have a relatively high negative charge and are stable against calcium-induced aggregation. Thereby, the κ-casein confers stability on the micelle by impeding aggregation, through electrostatic repulsion and steric hindrance.

Destabilisation of casein micelle

The stability of micelles is extremely sensitive to factors that alter the balance between hydrophobic attractive forces and electrostatic repulsive forces at their surfaces. The balance affects the micelle surface in terms of its attraction to, or repulsion of, neighbouring micelles. Destabilisation and aggregation of casein micelles are promoted by increasing the surface hydrophobicity either through enzymatic hydrolysis of the surface-κ-casein layer and/or by charge neutralisation (adjustment to isoelectric pH). A controlled, moderate degree of contact between the surfaces of touching micelles promotes the formation of a gel, which may be described as a protein network that occupies the full volume of the milk and encloses the fat globules and serum, analogous to the way that a sponge holds water. Conversely, a very high degree of contact and fusion between neighbouring micelles leads to the formation of a precipitate, which occupies only a very small portion of the total volume of the milk from which it is derived (<10%) and excludes serum and fat. For a given means of micelle destabilisation, the outcome in terms of gelation or precipitation is determined by a number of factors including, *inter alia*, concentrations of fat and protein in the milk, solvent quality (e.g., pH, ionic strength, type and level of salts), environmental conditions (temperature), and superimposed unit operations and their sequence (rate of heating/cooling, applied shear).

Exploiting casein aggregation to control the properties of dairy products

Rennet-curd cheeses

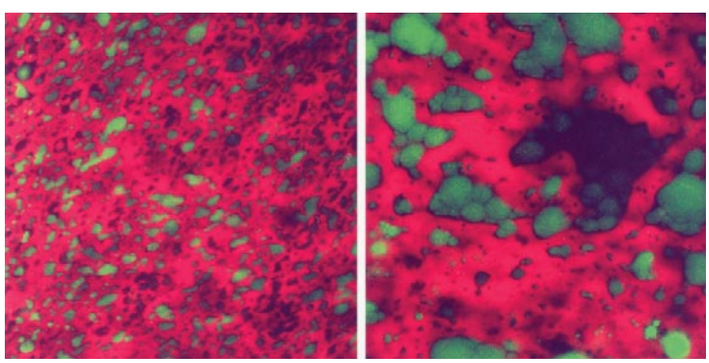
Hydrolysis of the micelle stabilising surface κ-casein layer by proteinases, referred to as rennets, is the basis for the manufacture of rennet-curd cheeses, which comprise about 80% of total cheeses manufactured and include well known varieties such as Cheddar, Mozzarella, Gouda and Emmental. The altered micelles are unstable and aggregate into a gel. Following gelation of the milk, further casein aggregation is promoted to reduce the moisture content from about 88% in the gel to 33-55% in the final cheese, depending on the variety. This is achieved by subjecting the gel to the interactive effects of various operations: cutting into pieces/particles, stirring, cooking and acidification of gel particles in whey; physical removal of whey (drainage); and, acidification, heating, salting, and/or pressing of the resultant curd mass. The resultant cheese may be defined as a highly concentrated amalgam of dehydrated para-casein micelles in the form of a matrix that encases the milk fat in the form of globules and/or pools. Controlling the degree of para-casein aggregation, through smart

manipulation of the different manufacturing steps and their sequence, is critical in defining the various aspects of cheese quality: ratio of viscous to elastic characteristics; texture; physical properties; and, applications. High levels of aggregation promote cheeses that are elastic, hard and chewy, have good shreddability and sliceability, and melt/flow moderately on heating. On the other hand, low degrees of aggregation favour higher moisture cheeses that are relatively soft, adhesive, spreadable, easily mixed with other ingredients, and flow extensively on heating. Other factors, however, also contribute to the architecture of cheese attributes, e.g., milk pre-treatments, starter cultures, added ingredients, maturation conditions, and macrostructure as affected by curd-handling treatments.

Researchers and dairy manufacturers both recognised that there is a deficit in the fundamental understanding of protein aggregation in high protein products. Two new Dairy Levy proposals aim to address this knowledge gap.

Acid-curd cheeses

The manufacture of acid-curd cheese products such as Cream cheese, Quark and Labeneh involves acid-induced gelation of milk and partial dehydration of the resultant gel using various operations. Ideally, these cheeses have a soft, smooth consistency, a creamy mouthfeel, and little or no free whey. However, owing to their relatively high moisture level (60-80%) and low contents of protein (10-14%) and calcium, these cheeses are inherently unstable, being susceptible to uncontrolled post-manufacture casein aggregation and dehydration via mobility and re-arrangement of their casein matrices when subject to stresses, for example during transport/distribution and retailing. This is the basis of major sensory defects, including excessive wheying-off and the development of sandy/grainy textures during storage. Avoidance of such defects requires optimisation of the degree of casein aggregation at the different stages of manufacture through the use of appropriate tools such as temperature, pH, ionic strength, whey protein denaturation and their complexation with the casein micelles prior to fermentation.



Micrographs showing the casein matrix (comprised of the casein network in red, and encased fat phase in the form of coalesced globules, in green) in full-fat cheese before and after heating to 85°C. Width of each micrograph corresponds to 150 micrometres. Microscopy images were produced by the National Food Imaging Centre, Teagasc, Moorepark.

Controlling the aggregation of whey proteins and their interaction with casein

Despite their relatively low content in milk, whey proteins can exert considerable influence on the heat stability and properties of dairy products, such as dairy-based beverages based on reconstituted skim milk powders, texture/mouthfeel of yoghurt and some fresh-cheese products.

The two main whey proteins, β-lactoglobulin and α-lactalbumin, have a globular, sphere-like structure in their native form but can quickly unfold when exposed to high temperature, as is the case during industrial processing. In the absence of casein, this unfolding (denaturation) leads to aggregation; first two proteins form dimers, then continue to grow to trimers, to small nanometre-size particles and, if not managed correctly, eventually to larger particles, which result in visible and undesired precipitation and coagulation. In the presence of casein micelles (as in milk), the heat-treated denatured whey proteins also interact with κ-casein to form β-lactoglobulin/κ-casein complexes that occur as filamentous appendages located on the micelle surface and/or as particles (<30nm) that are soluble in the milk serum. The location of the complex is influenced by pH and concentration of whey proteins during heating. Addition of whey proteins to milk prior to high heat treatment can selectively remove large portions of κ-casein from the casein micelles, leading to quasi-κ-casein-depleted casein micelles, which exhibit unusual properties. Irrespective of their type (appendages/particles) and location, the steric hindrance contributed by β-lactoglobulin/κ-casein complexes limits the degree of aggregation and fusion of casein micelles during rennet- and acid-induced gelation of milk, resulting in finer gel networks with lower porosities. While this is highly desirable in yoghurt and some fresh cheese products – where it contributes to a rich smooth creamy consistency/mouthfeel and greatly reduces syneresis – it is generally highly undesirable in rennet-curd cheeses as it leads to high moisture, impaired texture and physical properties, and poor flavour. It is, therefore, essential to understand and control the inevitable aggregation of whey proteins and their interaction with caseins in heat-treated applications. The main influencing factors are protein concentration and the quality of the serum phase, i.e., pH, ionic strength, presence of divalent ions (mainly Ca^{2+}, Mg^{2+}), viscosity or dielectric constant.

Knowledge gap

Researchers and dairy manufacturers both recognised that there is a deficit in the fundamental understanding of protein aggregation in high protein products. Two new Dairy Levy proposals aim to address this knowledge gap: (i) controlling protein aggregation in existing ingredients for milk gelation and designing 'smart' protein ingredients for the manufacture of gel-based products; and, (ii) using controlled protein aggregation for the development of 'smart' protein ingredients for functional beverages such as infant formula.

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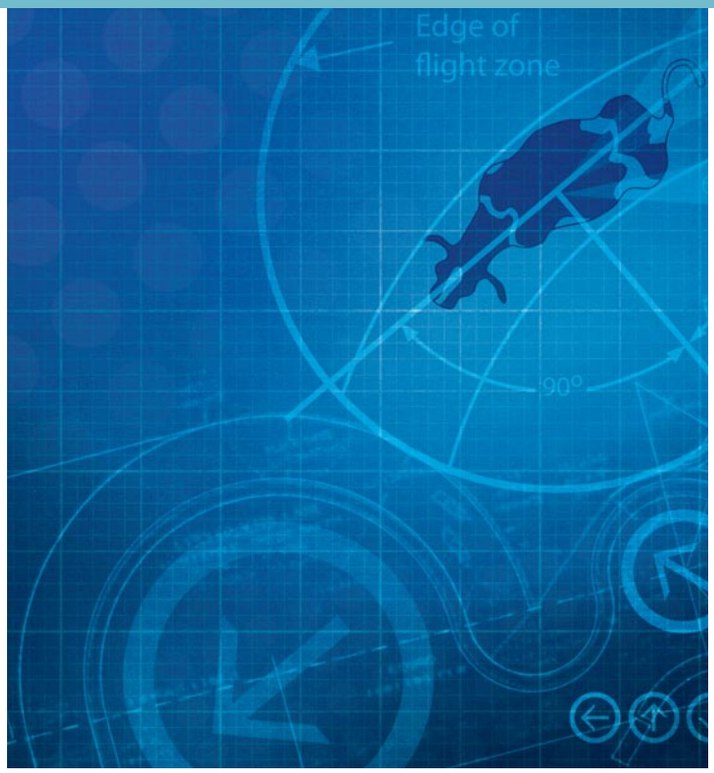
Safe handling of cattle on farms



Teagasc is applying its Research–Knowledge Transfer model to improve farmer safety and welfare of cattle.

Teagasc National Farm Surveys have indicated that farmer injuries associated with livestock herding and handling have increased and now account for 65% of all injuries. The trend of increased injuries when herding or handling cattle is attributable to the facilities used, less contact with animals arousing fear, and inadequate attention being given to breeding for docility. Teagasc is applying its Research–Knowledge Transfer model in association with the Health and Safety Authority and the Irish Cattle Breeding Federation to reduce the level of injury associated with livestock, while at the same time improving animal welfare.

Research

Teagasc participated in a European Union Leonardo da Vinci Livestock Safety Project where safety and related welfare issues of cattle handling were examined (Mazurek *et al.*, 2010). A review was undertaken of research related to safety/welfare with cattle, particularly focusing on the work of Professor Temple Grandin of Colorado State University, USA.

Fearfulness in cattle

It is well recognised that fearfulness is a major component that influences welfare for both animals and stockpersons. Husbandry management procedures, for example castration, dehorning of cattle and changes in their social and physical environment, may induce fear responses in animals. Contact between cattle and stockpersons has decreased, with increased mechanisation, size of herds and the number of farmers in part-time farming all resulting in less time allocated to animals by the stockperson. This means that animals may not have the same exposure to handling by humans and interactions could be limited. A poor human–animal relationship (HAR) leads to reduced animal welfare, which impacts on the productivity, quality and profitability of farm animals. Evaluation of the HAR is necessary to improve our understanding of animal welfare and safety issues in relation to the management of cattle on farms. There is a lack of scientific information on the relationship between the fear-related responses of cattle across time and in different test situations.

An animal's fear of humans is considered to be one of the most important indicators regarding animal welfare, but it is still unclear if fear is a personality trait or if it depends on the previous experience of the animal. To address this topic, four behavioural tests to measure and assess the fear responses of isolated heifers were performed on beef heifers: flight; docility; fear; and, chute tests.

The flight test measured the minimum distance an animal allowed a human to approach (avoidance distance) and the latency time to join peers. The fear test assessed reactions of heifers when: (i) alone in a pen with no visual contact to peers; (ii) alone with food with no visual contact to peers; (iii) in presence of a stationary human with no visual contact to peers; and, (iv) in presence of a stationary human and visual contact to peers. A chute test measured the behaviour of heifers during movement through a race. Seventy purebred Simmental heifers (mean (s.d.) 328 (40) kg) and 23 Simmental × Friesian heifers (mean (s.d.) 275 (57) kg) were used. Heifers were housed indoors for approximately 100 days. The flight (minimum approach distance), docility (responses of heifers to handling, while having no visual contact with their peers) and fear (four phases: responses of heifers in (i), the absence and (ii), the presence, of concentrate feed and, responses to a stationary human (iii) without and (iv) with visual contact with their peers), tests were carried out over three consecutive days, in that order, commencing on day 30 and again on day 80 post housing. The chute test (movement through a race) was performed on day 84 post housing.

Fear test – reaction to humans

Fear test procedure: one heifer was taken at random to the test pen and remained there for one minute alone (phase 1). The experimenter entered the pen and placed a feed bucket containing concentrates in the pen, and exited (phase 2). After 30 seconds, the experimenter entered the pen and positioned themselves 10cm from the feed bucket for 30 seconds (phase 3). After 30 seconds, a swinging gate was opened and the heifer was allowed to see its peers in the adjacent pen for 30 seconds (phase 4). The numbers in the squares represent the value assigned to the squares for the mean distance to stimulus calculation (**Figure 1**).

The results showed that heifers were more fearful during phases (i) and (iii) of the fear test and less fearful during phase (iv). When entering a novel environment (such as the fear test used in the study), the heifers showed greater fear levels than when the concentrate feed was offered. The most frightening event was the presence of the stationary human when the heifers could not see their peers. The fear scores were correlated across the flight, docility and fear tests, and were not correlated with the chute test. In conclusion, this study showed that fear responses of heifers vary over time and that fear is multidimensional, and thus, fear responses are condition specific (Mazurek *et al.*, 2011a; 2011b). Tests assessing the HAR should consider the conditions under which the tests are performed.

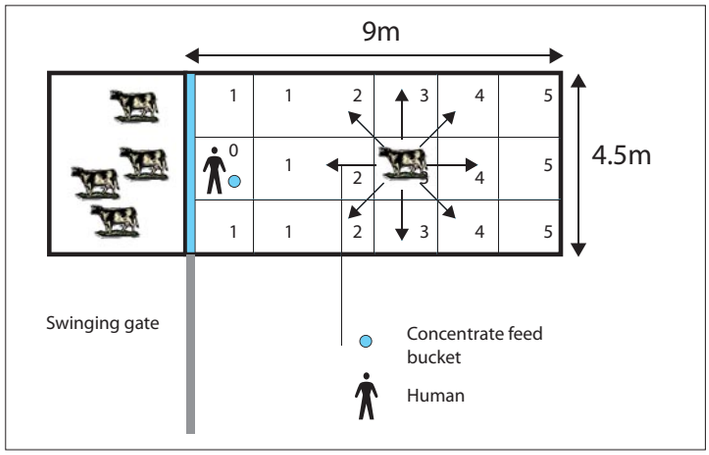


FIGURE 1: Fear test.

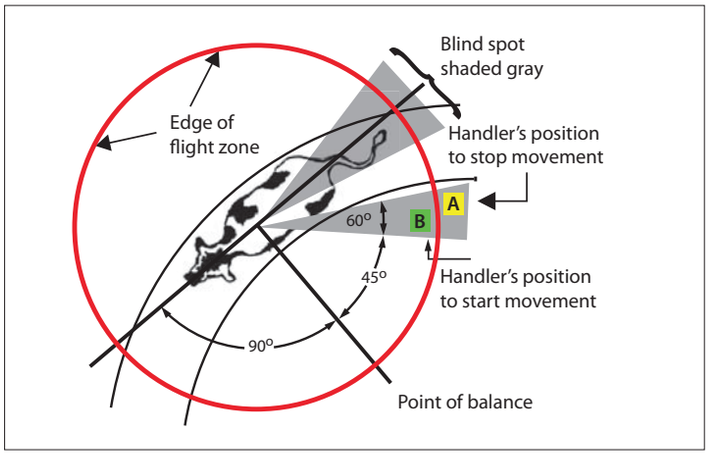


FIGURE 2: Flight zone and point of balance (after http://www.grandin.com/behaviour/principles/flight).

In summary:

- the stockperson has an important influence on the welfare of animals;
- fearfulness changes over time and is more related to the experience of the animals than to genetic factors;
- fear of isolation is more important for animals than fear of humans; and,
- the avoidance distance test is reliable to assess the quality of HAR using singly housed animals; however, in a group housed situation the behavioural responses of animals are influenced by the dominant animal in the group (Mazurek *et al.*, 2011b).

Professor Temple Grandin

Professor Temple Grandin is the leading animal behaviour scientist in the world and is based at Colorado State University, USA (see http://www.grandin.com/). Professor Grandin has the faculty to perceive and understand animal behaviour and her work indicates that handlers world-wide get animal behaviour wrong without specific understanding of the approaches required. She also considers that traditional handling facilities were not designed with animal behaviour in mind. A clear example of this is trying to drive cattle from the rear, where animals cannot see the person and can take flight. According to Professor Grandin, cattle handlers need to understand the concepts of 'flight zone' and 'point of balance' to be able to move animals more easily. The flight zone is the animal's personal space, and the size of the flight zone is determined by the wildness or tameness of the animal. **Figure 2** illustrates the general flight zone of an animal. The actual flight zone of an individual animal will vary depending on how 'tame' or 'calm' it is.

The point of balance is at or near the animal's shoulder and it is determined by the animal's wide-angle vision. This can be considered as the animal's 'centre of gravity'. An animal has better vision at this point and can observe movement towards them and can be easily influenced at this point. Animals will move forward if the handler stands behind the point of balance. They will stop if the handler stands in front of the point of balance.

Knowledge transfer

Teagasc and the Health and Safety Authority, with support from FBD Insurance plc., have produced a DVD entitled 'Guidance on the Safe Handling of Cattle on Farms' to assist farmers with conceptualising HAR and cattle behaviour, including the flight zone and point of balance. The DVD accompanies a Health and Safety Authority guidance document with the same title. The DVD also covers the following topics: facilities; safe handling at calving; loading of livestock; safety with a stock bull; and, breeding for docility. The DVD and guidance are available for use at training and education and advisory events, and can be downloaded from the Teagasc and Health and Safety Authority websites. Videos can also be be viewed on YouTube: *http://www.youtube.com/user/TeagascMedia*

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The impact of mastitis on farm profitability

A new study reveals that the cost of mastitis to dairy farmers is much greater than the penalties incurred.

Mastitis is a high-cost production disease and has been identified as a high-priority for action by farmers and industry experts through an Animal Health Ireland consultation process. There is a greater requirement by farmers to reduce production costs and remove avoidable on-farm losses to insulate against milk price volatility, which will inevitably be part of the production system of the future. There are large hidden losses associated with mastitis that are often underestimated at farm level. These losses include reduced milk production, higher rates of culling, increased mortality and lower herd growth potential. The cost of mastitis and the subsequent impact on profitability on Irish dairy farms has never been quantified. A study to examine the specific costs of mastitis in Ireland and the impact these costs have on farm profitability is being undertaken by Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, in partnership with Animal Health Ireland and University College Dublin.

Modelling

The Moorepark Dairy Systems Model (MDSM) simulates dairying systems inside the farm gate. In this analysis the MDSM (which is a stochastic budgetary simulation model of a dairy farm that allows investigation of the effects of varying biological, technical and physical processes on farm profitability) was utilised to determine the impact mastitis has on the profitability of Irish dairy farms as indicated by various ranges of somatic cell count (SCC). Farms were characterised by five SCC thresholds of ≤100,000, 100,001-200,000, 200,001-300,000, 300,001-400,000 and >400,000 cells/ml. The ≤100,000 cells/ml threshold was taken as the baseline and the other four thresholds were compared relative to this baseline. The cost components associated with mastitis that were accounted for in this analysis were: (i) reduced milk production; (ii) increased culling; (iii) increased clinical treatment; (iv) increased sub-clinical treatment; (v) increased veterinary visits; (vi) increased levels of discarded milk; and, (vii) penalties for SCC >400,000 cells/ml. The model estimated the total costs, total milk receipts and net farm profit for a 40 hectare farm across each of the five SCC thresholds, ≤100,000, 100,001-200,000, 200,001-300,000, 300,001-400,000 and >400,000 cells/ml.

Data

The biological, farm practice and cost data utilised in this analysis was taken from four sources:

1. PhD thesis completed by Kelly (2009) in which the association between SCC and milk yield on Irish dairy farms was examined.
2. &3. On-farm survey of clinical mastitis cases treated on a sample of 319 dairy farms who completed the Herd Ahead Survey, which was linked to the Irish Cattle Breeding Dairy Federation milk recording production data.
4. On-farm survey of farmers' use of diagnostics, treatment practices, discarded milk and culling for mastitis. This survey was administered to a sample of 78 dairy farmers who participated in the Herd Ahead Survey.

Cost components

The data for each cost component included in the analysis is summarised in **Table 1**. This biological data was incorporated into the MDSM model along with cost data. Milk production loss increased as SCC increased. The milk production loss was based on individual cow test day SCC records extracted from the ICBF database over a three-year period (2003-2005). In total, 235,163 test day records from 23,791 dairy cows, in 366 herds, were used for the analysis. Milk production loss per cow per annum ranged

Table 1. Treatment practice assumptions per somatic cell count threshold.

Assumptions	<100,000 (Baseline)	100,001-200,000	200,001-300,000	300,001-400,000	>400,000
Milk production loss, L/lactation length[1]	177	351	485	544	601
Testing					
% of farms carrying out bulk tank milk cultures[2]	1	2	1	1	1
% of farms carrying out individual milk cultures[2]	1	3	1	4	8
Cases treated					
% of clinical cases treated[3]	11	15	21	29	38
% of sub-clinical cases treated[2]	1	1	4	2	1
Discarded milk and culling					
% of farms discarding milk[2]	12	17	24	32	39
% of herd culled due to mastitis[2]	3	5	9	11	13

[1] Source: Kelly (2009); [2]Source: Mastitis Farm Practice Survey; [3]Source: Herd Ahead Survey.

Table 2. Impact of mastitis on the physical outputs of Irish dairy farms across five somatic cell count (SCC) thresholds, holding land area constant.

Model outputs	<100,000 (Baseline)	100,001-200,000	200,001-300,000	300,001-400,000	>400,000
Land area, hectare	40	40	40	40	40
Cows calving	94	96	99	100	101
Stocking rate	2.62	2.66	2.68	2.69	2.70
Milk delivered, kg	532,122	524,614	518,834	516,198	513,596
Replacement rate, %	19	20	24	26	28
KgMS, kg	37,530	36,995	36,573	36,380	36,190
Milk receipts, €	148,843	146,717	144,550	141,279	138,573
Livestock receipts, €	43,304	44,900	47,792	49,153	50,519
Total farm receipts, €	192,147	191,617	172,749	190,431	189,091
Total farm costs, €	161,085	164,994	173,120	173,536	177,343
Net farm profit, €	31,252	26,771	19,661	16,936	11,748

between 177 litres for an SCC <100,000 cells/ml to 601 litres for an SCC >400,000 cells/ml. The proportion of the herd culled due to mastitis increased as the SCC increased. Farms with an SCC ≤100,000 cells/ml culled 2.81% of their herd as a result of mastitis, while this figure increased to 12.57% of the herd with an SCC >400,000 cells/ml. All up-to-date costs and prices were included in the analysis.

Mastitis costs

The effect of reduced milk production per cow associated with increased SCC levels was magnified by the increased culling levels. Higher culling resulted in more first and second lactation animals and fewer mature cows in the herds with higher SCC levels. As the SCC level increased the milk yield per cow declined while the farm area remained at 40 hectares. Less feed was required for each cow (lower milk yield), therefore there was increased capacity to manage additional cows on the farm. As SCC increased, overall milk sales from the farm declined, as there were more cows on the farm producing less milk (primiparous cows replaced multiparous cows).

As SCC increased, total milk receipts decreased due to reduced milk production as SCC rises. Total livestock receipts increased as SCC increased due to the higher level of culling. As a result total farm receipts decreased as SCC increased, even though there were higher numbers of cows, as SCC increased the total receipts from the farm were reduced. Total farm costs increased as SCC increased, which was mainly associated with increased culling and therefore an increased requirement for replacement animals, and increased treatment costs. As a result, as the SCC increased, the net farm profit decreased from €31,252 at an SCC <100,000 cells/ml to €11,748 at an SCC >400,000 cells/ml. On the 40 hectare farm modelled in this analysis, at an SCC of >400,000 cells/ml, farm profit decreased by 62% relative to the baseline (<100,000 cells/ml).

The costs of labour were excluded from the analysis presented here due to the lack of specific data on the labour time required to treat and manage mastitis herds in Ireland. However, in an expanding dairy industry an increased incidence of mastitis could reduce the number of cows that one individual could handle; therefore, labour would then have a considerable economic effect. The impact SCC has on the fat, protein and lactose content of milk has not been incorporated in this analysis due to the variability in the literature. However, this issue will be examined more closely in a future analysis on the impact of SCC on processor returns. Mastitis has implications at processor level as well as at farm level in terms of reduced milk quality, reduced product yield, flavour change and reduced shelf life. Each of these factors will impact customer satisfaction, product rating, product market value and ultimately the returns to processors and producers. Quantifying the impact of mastitis on processor net returns utilising a milk processing sector model (Moorepark Processing Sector Model – MPSM) is the next step of this analysis, which will facilitate milk pricing strategies that reflect the real effect at processing level.

Benefits to the industry

In order for Irish dairy farmers to prosper in a highly competitive post quota environment, unnecessary on-farm costs and losses need to be minimised. In many situations the belief is that mastitis is not a significant cost, based only on the penalties incurred. However, this study has shown there are significant costs, which will be magnified in a no-quota situation. Quantifying the costs of mastitis to demonstrate the losses occurring on Irish dairy farms is an important step in motivating farmers to acknowledge the scale of the problem and implement effective management practices aimed at improving mastitis control and reducing the associated costs. Mastitis costs are significant on farms, with the actual penalties incurred accounting for only a fraction of the overall costs (accounting for 0-3.4% in reduced milk receipts across the SCC thresholds). With the impending removal of milk quotas and increased pressures on farm labour, focusing on mastitis control strategies to lower herd SCCs will allow increased milk production per cow, reduce culling, lower costs and thus facilitate profitable expansion post quota.

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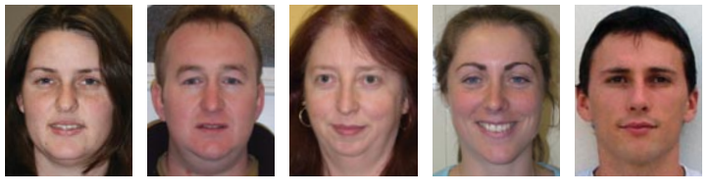

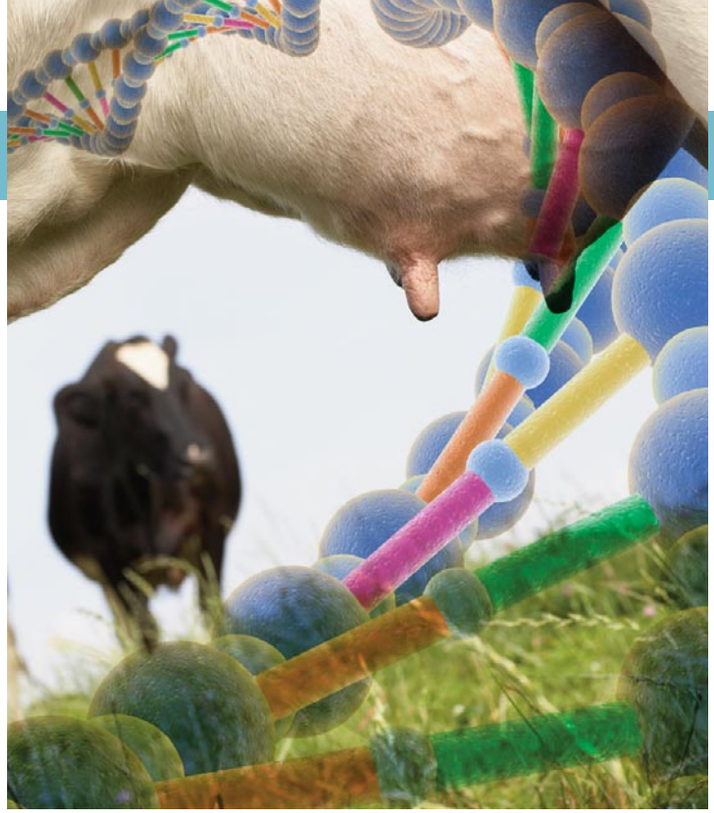

Integrating basic and applied research on mastitis

Researchers at Teagasc's Animal & Bioscience Research Department are taking a multidisciplinary approach to the control of mastitis. They are using a number of complementary technologies to understand the disease and to ensure that research results are applicable on farm – both in the short term and in the future.

The Teagasc Animal and Bioscience Research Department (ABRD) has been established to bring together a multidisciplinary team of both existing and newly recruited researchers to drive research, development and innovation in the area of animal science. This diverse team focuses on four major research themes: health and welfare, nutrition, fertility and breeding, and has expertise in a wide range of fields, including genetics, physiology, animal management, nutrition, reproductive biology, molecular biology, immunology, microbiology, genomics, proteomics, and computational and systems biology. These diverse skill sets will be necessary to investigate and understand complex issues that impact on competitive and sustainable production and to translate new insight from this research into innovative solutions for the agri-food sector.

Multi-factorial challenges – for example achieving and sustaining excellent animal health – require multifaceted solutions that can only be achieved through intensive integration of knowledge and expertise from a diverse spectrum of research efforts and through national and international collaboration. In this article, we focus on mastitis, as an example of how researchers at the ABRD are tackling these complex issues.

Mastitis

Mastitis is estimated to cost the dairy industry €25 billion worldwide annually. Nationally, mastitis was ranked second only to (and probably contributing to) infertility in a recent Animal Health Ireland Delphi survey on prioritisation of non-regulatory animal health issues. Subclinical infections add substantially to the economic damage that this disease can do. The Teagasc road map for the future of the Irish dairy industry predicts a substantial increase in the size of the national dairy herd to about 1.4 million cattle by 2018. This expansion will herald a new impetus in the control of infectious diseases in general, and mastitis in particular.

Mastitis has a complex aetiology, with a number of major factors contributing to disease status, such as the pathogen, the host and the environment. Because this disease has such a complex set of causal factors, as well as complex presentations in clinical and subclinical forms, preventing and managing it is not a simple task. A routine indicator used for infection is a cow's somatic cell count (SCC), although the correlation between the numbers of cells in milk and disease is not absolute.

An integrated research approach

Biosecurity and on-farm practice

Good management practice has always been, and will continue to be, the cornerstone of animal health management. Animal Health Ireland (an industry-led, not-for-profit partnership between livestock producers, processors, animal health advisers and government) recently developed CellCheck, the national udder health initiative. The primary objective of the CellCheck programme, which is being managed by Teagasc Research Officer Dr Finola McCoy, is to reduce the SCC of the national herd in a sustainable way. Currently, a wealth of knowledge exists within the dairy industry in relation to mastitis control. There is a need, however, to collate this knowledge into a single source accessible to all. CellCheck will produce agreed, clear and consistent messages and guidelines, which are independent and evidence based. This science will be delivered to the industry through service provider training, farmer workshops and regular technical communications. In addition to good management practice a number of complementary novel research programmes in the ABRD are addressing the major factors that contribute to mastitis.

The contribution of bovine genetics

We are currently using genomic selection to select dairy bulls with superior milk production traits. Included in this selection index are health traits including SCC, which over time will reduce the SCC levels in the national herd. There is potential, however, to include other health traits that could enhance the progress made with selection for reduced subclinical mastitis. However, because of current limitations such as the lack of clear, nationally recorded, reliable health phenotypes, low measurable contribution of genetics to some health traits (low heritability) and the complexity of mastitis infections, we need to incorporate bioscience approaches to understand the biology of traits. Drs David Lynn and Donagh Berry (ABRD), in collaboration with Professor Dan Bradley (TCD), have recently been funded by Science Foundation Ireland (SFI) to exploit new technologies (next generation genotyping and sequencing) to investigate the association of genetic variation with mastitis. Dr Kieran Meade has also been funded by SFI to study the impact of genetic polymorphisms in key immune genes on an animal's ability to fight infections, including mastitis. In conjunction with Dr Rachel McLoughlin and Professor Cliona O'Farrelly (TCD), the identification of such genetic markers may allow the future selection of animals with a superior ability to resist intramammary infection.

Genetic and molecular mechanisms of immune response

The animal's response to infection is actually a collection of transitional responses across multiple biological levels. Measuring the RNA (transcriptome), protein (proteome), and intermediates (metabolome) provides a hierarchy of intermediate phenotypes, which not only help us to understand the complex biology of mastitis, but simultaneously identify potential markers that could be useful in selecting animals with disease resistance.

Dr Kieran Meade is also working on the epigenetic mechanisms that may contribute to the development of chronic infection and the establishment of mastitis disease. Previous infection history can interfere with an animal's ability to fight a current infection, through methylation-mediated silencing of inflammatory genes. Manipulation of the epigenome may become a useful tool towards boosting an animal's response to mastitis vaccines.

Dr David Lynn is profiling the expression of novel genetic markers (microRNAs) with the objective of adding another layer of understanding of the immune response to mastitis infection. In humans, microRNA expression has been used to classify different types of cancers, highlighting how basic scientific research can quickly have practical application.

Effect of environment on disease susceptibility

The ability of an animal to cope with environmental challenges is the result of interactions between genotype, environment, and the effects of prior environments on gene expression profiles, cellular and physiological function. In this regard, stress is emerging as a critical factor in determining the outcome of mastitis infection.

Dr Bernadette Earley is researching biomarkers of stress and methods for accurate measurement that may provide tools to reduce stress-associated disease susceptibility in cattle.

Understanding animal–pathogen interactions

The nature of the infecting micro-organism will impact not only on an animal's ability to fight infection, but also on the success of diagnostics and the response to treatment. Dr Orla Keane, in collaboration with Dr Finola McCoy (ABRD), Dr Jennifer Mitchell (UCD) and Professor Lorraine Sordillo (MSU), is profiling the mastitis-causing pathogens in Ireland and estimating their clinical incidence and seasonal nature. A key aim of Dr Keane's research at the ABRD is to identify virulence factors mediating disease in cattle and characterise the interaction of these virulence factors with the bovine immune system.

Towards a comprehensive model of mastitis

Understanding the multiple layers of information contained in each layer of the biological response generates a plethora of data at genetic, genomics (transcriptomic) and proteomic levels. Integrating this data in a way that enhances understanding of the organism and its interactions (with pathogen and environment) is the task of what is known as systems biology.

Dr David Lynn, working with the United States Department of Agriculture's National Animal Disease Center, aims to implement a systems biology approach to profile the host response to a bovine mastitis pathogen (*Streptococcus uberis*) in milk-isolated monocytes, over a time course of infection, at the transcriptional (RNA-seq), post-transcriptional (miRNA-seq), and translational (mass specrometry proteomics) levels. This data will be integrated into a common molecular interaction network and pathway framework to provide novel insight into the gene regulatory and signalling networks involved in the early host response in a mastitis infection model and will enable a network-based approach to identify potential new therapeutic targets for this important production disease.

Translating research into deliverables

In the short term, the results from the research in the ABRD will be delivered in terms of enhanced biosecurity measures and on-farm management tools. An international research group, including Teagasc and the Irish Cattle Breeding Federation, is investigating the development of decision support tools to integrate and summarise data from multiple sources into easy to interpret management tools for farmers.

In the longer term, understanding the complexity of mastitis disease will allow us to tease apart the component traits more accurately, generating better phenotypes and diagnostic biomarkers. Comprehensive science-led development of a basic research programme can lead to new translational opportunities that were previously unforeseen. New technologies may help to identify novel biomarkers that more closely correlate with disease, especially during the critical subclinical stage. New targets for mastitis therapy include the development of new mastitis vaccines; targets for animal selection schemes and knowledge-based management decision tools are all potential deliverables to the industry from the ABRD research programme. Building a bioscience research platform complementary to existing research streams in Teagasc will aid the integration of scientific and management tools that will ultimately reduce the burden of this disease.

ABRD building a secure foundation for the future

The ABRD has many strengths including multidisciplinary expertise, national (ICBF, AHI, universities) and international partners and new state-of-the-art facilities for performing targeted animal trials and studies to define and refine new diagnostics, therapeutics and breeding strategies for the future. It is well recognised that gains in any other area of animal production, e.g., enhanced production or reproduction, can only be maintained in the context of optimal animal health management. In line with the EU strategy on Animal Health – entitled "prevention is better than cure" – research at the ABRD can facilitate a national proactive approach towards providing the agricultural industry with tools not only to treat current mastitis disease but also to prevent future problems that may occur in the context of the expansion of the national herd. Science-based innovation support in the agri-food sector and broader bio-economy requires excellence in knowledge generation and procurement (research), knowledge transfer (advisory activity), and knowledge absorption (education and training). The ABRD is a key resource in this regard.

For further information, log on to www.teagasc.ie/animalbiocence.

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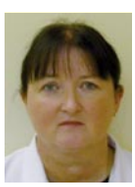


New dairy farms

In response to EU milk quota abolition, newly emerging dairy farm businesses are changing the landscape of the Irish dairy industry forever. A multi-disciplinary research project, part funded by AIB Bank, is studying the characteristics of these new business developments.

The anticipated 50% increase in national milk production post EU milk quota abolition is based on the presumption of increased scale of existing dairy farmers as well as an increased influx of new entrants to the Irish dairy industry. This expansion will increase the profitability of Irish dairy farms, create valuable new jobs within the national dairy industry and, combined with value added at processing level, will be worth in excess of €1 billion to the Irish agri-economy in the next decade. As we approach quota removal, EU milk quotas are being expanded by 1% per year between now and 2015 and, as part of the Irish milk quota expansion policy, the Irish Government has decided to allocate one-quarter of this annual 1% increase in milk quota to new entrants. Approximately 230 new stand alone dairy farm businesses have successfully received 200,000 litres of milk quota from the scheme in its first three years. The superior profitability of dairying has made this an attractive opportunity for farmers in other low margin enterprises and the number of applications to the scheme increased significantly each year, exceeding 200 applications for the first time in 2011. As part of the application process, each successful new entrant applicant provided a detailed five-year business plan incorporating physical and financial plans in addition to information on the location of their planned enterprises. This group of new dairy producers represents the initial evolution of the dairy industry in Ireland post EU milk quotas, and provides a unique opportunity to examine the characteristics of new dairy producers entering the industry in Ireland.
The objective of this study is to examine the characteristics of new dairy producers, and to investigate the processes influencing the adoption of dairy technologies among new dairy farmers.

A profile of new entrant dairy farmers

Since 2009, over 230 new dairy entrant applicants have been accepted into the scheme. The data submitted by the applicants provides the study with a general characterisation of new entrants in terms of location, projected scale, experience, existing resources, previous enterprises and expectations for the future. With the technical assistance of GIS mapping, the geographic distribution of a sample of the new dairy farms is highlighted in **Figure 1**. The map highlights the density of newly established dairy farms in the southern half of the country, with the majority of new entrants (81%) located in the south and south east, and the balance distributed in the border, midlands and west (19%). It is apparent from **Figure 1** that the majority of new entrant dairy operations are developing within the traditional dairy areas in the south, with fewer applicants in the midlands and west of Ireland. Also from our analysis, a profile of the average new entrant is outlined in **Tables 1 and 2**.

Over half were previously in beef production with the majority of the remainder coming from a mixed farming enterprise (combining sheep, beef and tillage). With an average farm size of 70 cows on 58ha, the new entrant farms will be lowly stocked during the initial years of the new business. However, there is significant potential for milk production expansion on these dairy farms in the future.
The average budgeted infrastructure investment on these new dairy farms is €188,000 with the majority earmarked for the development of milking parlours, animal accommodation and the purchase of dairy stock. This capital investment plan initially appears to be a conservative estimate of the set-up costs. However, 35% of the applicants are developing their new enterprises on farms that were previously in dairying and so may already have some of the necessary infrastructure in place. The planned infrastructural investment will largely be funded by borrowings (~€88,000) in addition to savings and the sale of existing stock from the previous enterprise. In terms of the predicted financial performance, the gross output is estimated at 30 cents per litre (c/l), including an average milk price of 27c/l and 3c/l for the sale of bull calves and cull cows (**Table 2**). On average, new entrants plan on production costs of 25c/l resulting in profitability of 5c/l, equivalent to €422/ha or €677/cow. While this appears to be a relatively poor return on investment, these new dairy farms will be considerably more profitable than non-dairy enterprises of comparable size and have significant potential to increase profitability in the future using the infrastructure that will have been put in place during the initial set-up.

Table 1. General characteristics of the average new entrant dairy farmer over the next five years, from the successful application forms of 2009 and 2010 applicants.

General characteristics	Average
Age (yrs)	36
Farm systems characteristics	
Land area farmed (hectares)	58
Herd size (no. cows)	70
Replacements (no. heifers)	24
Stocking rate (LU/ha)	1.74
Milk yield (litres/cow)	4,950
Milk solids (kg/cow)	381
Total annual milk supply (litres/farm)	352,000

Factors affecting new entrant success: a mixed methods approach

It is vitally important that new entrants develop successful businesses within the dairy industry. Many factors are likely to influence the success of these new businesses, namely: the level of investment in infrastructure; the efficiency of production; the rate of expansion in production; and, external cost pressures such as interest and inflation rates. The success of these farms will be assessed using a mix of qualitative and quantitative methods combining biological and financial information with attitudinal responses and experiences in relation to dairy farming. Each new entrant is required to complete a financial statement at the end of each year and the evaluation will include an analysis of these financial statements. Performance data will be compared against the business plan projections. In addition to looking at actual performance, the financial implications of alternative expansion strategies for new dairy entrant enterprises will be modelled using the Moorepark Dairy Systems Model (Shalloo *et al.*, 2004). The data collected from the successful candidates over the initial three years of the scheme will provide background information, which will be used to model alternative business development approaches. Several scenarios will be evaluated based upon varying rates of new farm expansion, levels of infrastructural investment, super levy risk and repayment strategies. The outcome of this analysis is to identify the key financial considerations (in terms of both profitability and cash flow), which will have the greatest impact on the success of the business in the first 10-15 years of its development. Methodologies such as attitudinal surveys and qualitative interviewing will be used to investigate the attitudes and experiences of new entrants in how they adopt new dairy technologies. The adoption of key grazing management and genetic improvement technologies are critical in aiding new entrant farmers to develop a successful dairy enterprise and achieve a competitive advantage over other producers. Farmers' learning of and experiences of adopting new technologies will be examined during the initial six to 12 months of the farm business development, and again 18 months later, to analyse changes. It is hoped that by using a mixed methods approach, in-depth information on farm performance and technology adoption will be combined to provide some insight into the factors affecting the success of new entrants to the dairy industry.

Conclusion

There is now major interest in the new entrant dairy scheme arising from the superior profitability of dairying in comparison to the other enterprises. There is a significant regional trend in new entrant applications with the majority emerging from the south east. While these farms are likely to operate as lowly-stocked farm systems in the initial years, they have considerable potential to expand once quotas are removed. With over 350 new entrant dairy farmers expected to establish by 2015 through the New Entrant Scheme, the investigation of the barriers to new business development will provide important information for potential future entrants to the industry.

Acknowledgements

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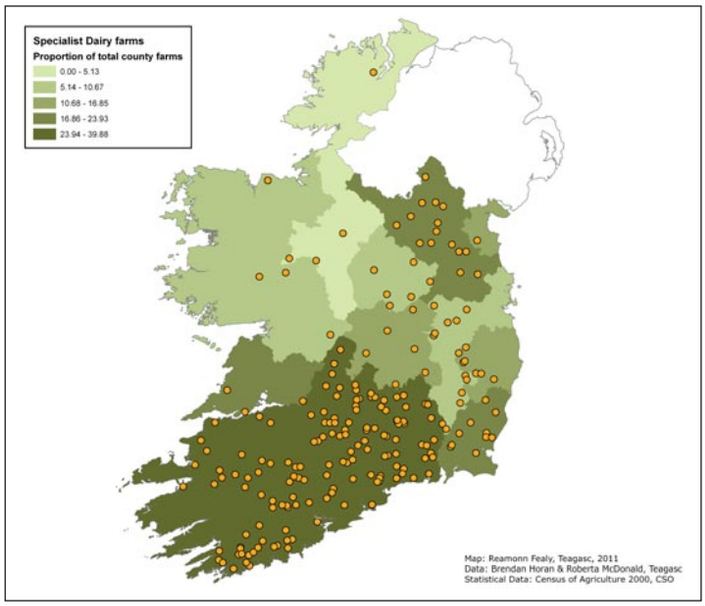

FIGURE 1: Geographic distribution of new entrant dairy farms in Ireland during 2009, 2010 and 2011 in relation to the proportion of national specialist dairy farms.

Table 2. Financial performance of the average new entrant dairy farmer over the next five years, from the successful application forms of 2009 and 2010 applicants.

Financial projections	cent/litre (c/l)
Gross output	30
Total variable costs	13
Total fixed costs (incl. depreciation and interest)	12
Net profit	5

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Can beef from dairy bulls be profitable?

Given the upcoming abolition of milk quotas in 2015, a number of different systems of dairy bull beef production are being evaluated at Johnstown Castle Research Centre.

The impending abolition of milk quotas in 2015 is expected to prompt significant expansion in the national dairy herd. Hence, a substantial increase in the supply of dairy bull calves is anticipated. Defining blueprints for dairy beef production systems is critical to profit generation from dairy-calf-to-beef enterprises. Currently, there is renewed interest in dairy beef production. Pre decoupling of support premia, steer production was generally more profitable than bull beef production, mainly due to the higher premium earning capacity of steers. However, rearing males as bulls has inherent efficiencies due to their higher production potential. Numerous systems could be considered for bull beef production: rosé veal (less than 12 months of age): less-than-16-month; 19-month; and, 22-month production systems. On the other hand, there is a perception that meat from older bulls is of inferior sensory quality and market demands dictate that bulls in the less-than-16-month production system produce the most desirable product. The dairy-calf-to-beef programme, established in Johnstown Castle in 2010, is examining the performance of dairy bred bulls across various production systems.

Research at Johnstown Castle

In 2010, 300 spring-born calves were assembled at the Johnstown Castle research centre. Animals were evaluated across a range of production systems (**Figure 1**). Sixty calves were immediately housed on a diet of meal *ad libitum* with straw as a source of roughage. The remaining 240 calves were turned out to pasture; half of these were offered 2kg of concentrate per head per day, with the remaining 120 calves on a pasture-only diet. The objective of these production systems was to ascertain the maximum growth potential, as well as the lifetime effect of concentrate supplementation, for the first season at pasture. Each treatment group consisted of Holstein-Friesians (HF) and crossbred calves (primarily Jersey × Holstein-Friesian with a small number of Norwegian Red × Jersey × Holstein-Friesian). These are denoted as JEX.

Eight-month system

Animals were slaughtered at eight months to develop carcass profiles and also to investigate the potential of this system for niche markets. Three groups (90 calves) were finished just under eight months of age, 30 calves from each treatment: calves on meal *ad libitum* indoors; calves at pasture plus 2kg concentrate; and, calves on pasture only.

Live weight at slaughter was 264, 206 and 149kg, which yielded carcass weights of 126, 96 and 61kg for the calves indoors on concentrate *ad libitum*, calves supplemented with 2kg at pasture and calves on the pasture only diet, respectively. It should be noted that animal performance was below target due to a disease outbreak in 2010.

Twelve-month system

Of the 60 animals that were housed and offered meal *ad libitum*, the remaining 30 were slaughtered at 12 months of age, thus providing data for a further four months' intensive finishing. Concentrate dry matter (DM) input was 1.48 tonnes (t) per animal. Live weight at slaughter for the treatment group was 400kg with a carcass weight of 202kg.

Under 16-month system

Of the 120 animals that were each allocated to the pasture only and pasture plus 2kg treatments during the first season at pasture, a further 30 of each were slaughtered at less than 16 months of age. This production system reflects market requirements. These animals were built up onto an *ad libitum* diet at housing after the first season at pasture. Animals were on meal *ad libitum* for 207 days and slaughtered according to age in May and June 2011. Estimated individual concentrate DM intakes during the finishing period was 1.61t for both treatment groups. Live weights at slaughter were 448 and 481kg, which yielded carcass weights of 234 and 253kg for the pasture only and pasture plus 2kg groups, respectively. While this production system meets market requirements, it may not be profitably achieved from grass-based production systems (Crosson and O'Riordan, 2011).

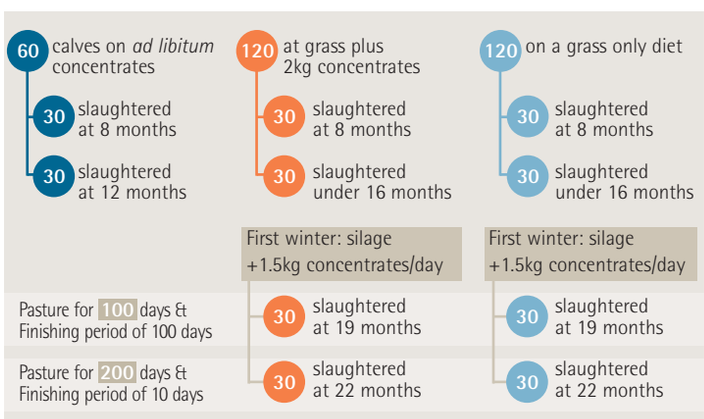

FIGURE 1: Finishing systems for the dairy bull beef experiment 2010.

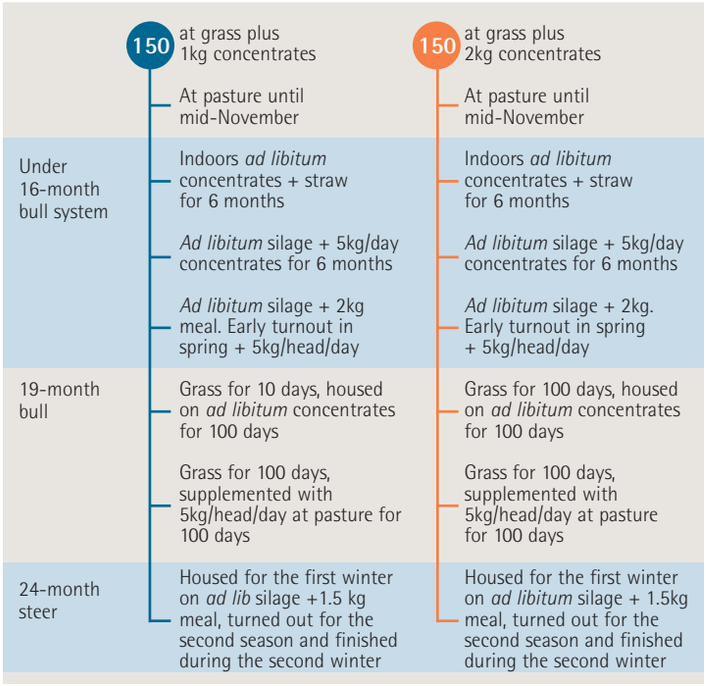

FIGURE 2: Finishing systems for dairy beef experiment 2011.

Nineteen-month system

Animals in this production system were turned out to pasture for a second grazing season for 100 days and were subsequently housed and finished on meal *ad libitum* for a 100-day period. Estimated individual concentrate DM intakes of these animals were 1.25 and 1.16t for the pasture only and pasture plus 2kg, respectively. Live weights at slaughter were 573 and 587kg for the pasture only and pasture plus 2kg groups, which yielded carcass weights of 300 and 309kg, respectively.

Twenty-two month system

This system reflects the majority of bull beef production employed by commercial producers. Bulls in this production system were turned out to pasture for 200 days in the second grazing season, housed and finished on meal *ad libitum* for a 100-day period. Estimated individual concentrate DM intakes of these animals was 1.45t for both treatment groups. Live weights at slaughter were 606kg and 645kg, which resulted in carcass weights of 327 and 345kg for the pasture only and pasture plus 2kg groups, respectively.

Breed differences

Differences between breed groups indicate similar performance between HF and JEX at pasture. However, HF had greater average daily gains across all finishing periods with higher kill-out proportions compared to the JEX. Typically, carcass weights of JEX were 30kg lighter than the HF.

Research developments

In 2011, more emphasis was placed on the comparison between less-than-16-month, and 19-month production systems and the conventional 24-month steer system. Over the course of May 2011, 300 calves were assembled at the Johnstown Castle unit. Twelve treatment groups were established. The finishing systems are detailed in **Figure 2**.

Six groups will be slaughtered at less than 16 months of age. Due to the intensive *ad libitum* feeding systems operated in 2010, alternative finishing strategies are now being investigated.

Two groups will be housed on a diet of good quality *ad libitum* silage plus 5kg of concentrate. The remaining groups in the less-than-16-month production system will be turned out to pasture in spring and supplemented with 5kg of concentrates per head per day.

Animals in the 19-month production system and 24-month steer system will be turned out to pasture for a second season. Two groups will be turned out to pasture for 100 days, housed in June and given a 100-day finishing period. The remaining groups in the 19-month production system will be allocated 5kg of concentrates per head per day at pasture for 100 days. Animals in the steer system will remain at pasture for the second grazing season and will be finished during the second winter.

Data has been presented from the first year of the study, the objective of which is to develop systems of production resulting in a product that is profitable to the producer and marketable for the processor. Initial results indicate that production systems evaluated to date are highly sensitive to concentrate input price. Further research is being initiated to explore avenues of reducing costs within these systems. While the current study is evaluating the production performance of dairy-born bulls across a range of production systems, the ongoing research undertaken at the Teagasc Food Research Centre, Ashtown investigating the meat sensory characteristics is essential to capture potential differences that may exist between these production systems.

Acknowledgements

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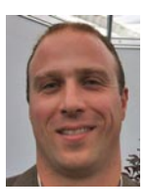



Food choices – what's my motivation?

Research is ongoing at Teagasc, in collaboration with University College Cork, to better understand and predict consumer behaviour in relation to food and health, as well as to derive evidence-based recommendations for key stakeholders.

Never before has healthy eating been so important to consumers. Not only do good food choices lead to better overall health and a reduction in diet-related diseases, they also make good economic sense for both our own pockets and the Government's purse. Awareness of the relationship between health and nutrition is high, yet despite recommendations to maintain a healthy weight and increase fruit and vegetable consumption, the prevalence of obesity has increased and fruit and vegetable consumption has remained relatively unchanged in Ireland during the last ten years (Irish Universities Nutrition Alliance, 2011). It is therefore no surprise that diet-related lifestyle diseases are predicted to rise by 40% over the next 10 years in Ireland (Balanda *et al.*, 2010). This begs the question as to why consumers are not behaving in a healthier manner. One of the possible reasons is that food products and health messages are not sufficiently specific and targeted to certain subgroups of the population. If more targeted messages or food products were used, where specific groups for targeting were more clearly defined and characterised, consumer knowledge might then be translated into behaviour. A commonly used approach in marketing to characterise target consumer groups is known as segmentation. Segmentation identifies distinct consumer or market segments with similar characteristics in terms of attitudes, behaviours or preferences. It can also be an effective tool to identify differing subgroups for targeted intervention programmes. These targeted interventions, which can be undertaken by both the food industry (through new product development) and government (at a policy level), are required to facilitate healthier dietary choices that can combat the increasing prevalence of lifestyle diseases.

What motivates us to eat?

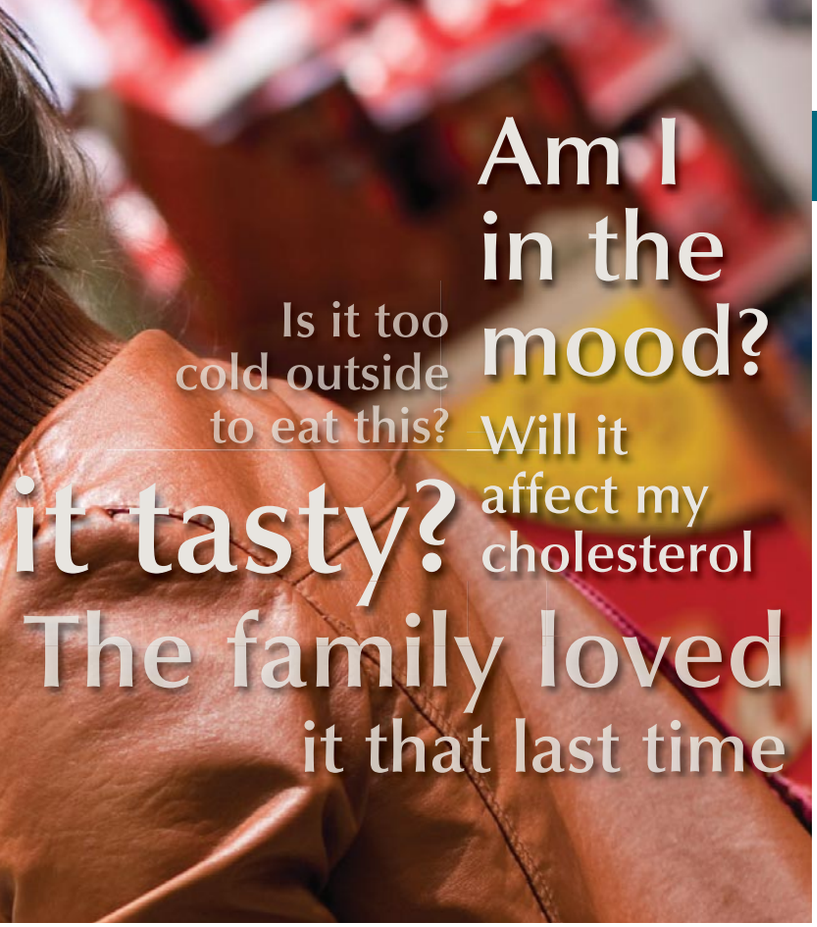
The drivers of food choices are very complex, interactive and dynamic. Research at Cornell University in the United States has shown that the average consumer makes approximately 200 food decisions each day. During the fleeting time period it takes to make these decisions, the consumer goes through a mental set of learned rules (also known as heuristics) based on previous experience and immediate needs ranging from price, taste, mood, health, weather and friends to image; the list is endless. So what is driving or motivating these decisions and can consumers be segmented based on these motives?

Measuring food choice motives

The National Adult Nutrition Survey (Irish Universities Nutrition Alliance, 2011) was recently completed by a multidisciplinary team from University College Cork (UCC), University College Dublin (UCD), the University of Ulster and Teagasc. It is a nationally representative database of habitual food consumption, consumer food choice attitudes, motives and biological measurements (e.g., weight, blood pressure) in 1,500 Irish adults over 18 years of age. This survey is one of the first to collect extensive food choice attitudinal data at the same time as consumption data for the same respondents and is one of the most comprehensive food databases available in Europe. Food choice motives and attitudes were collected using a questionnaire, which was developed and designed at Teagasc and UCC. It contained attitudinal statements relating to food choice motives, healthy eating habits, attitudes towards healthy eating, dietary optimism and dietary change. A ranking question was also included in the questionnaire, where respondents were asked to rank in order of importance a range of food choice preferences when making their food choice. These preferences were taste, cost, health and nutrition, convenience, mood and weight control. A combination of statistical segmentation techniques, including factor and cluster analyses, were used to segment the data.

Do different segments exist?

Three distinct segments were identified based on different food choice motives. These segments were then profiled and named based on age, gender, ranked food choice preferences and health-related attitudes. The first segment was the smallest at 17% of the population. It was named 'uninvolved juniors', as this group tended to be younger, had a high proportion of men and was driven by taste and convenience. The second segment was the largest one at 46%, and was named 'all rounders' because members were motivated by many factors in their food choice. The third segment accounted for 37% of the population and was named 'healthy seniors'. This had a higher proportion of the population aged over 50 years and placed high importance on diet and health attitudes. **Figure 1** illustrates how the total population and each of the three consumer segments varied in the food preferences that they ranked first. For the total population, taste was ranked as the most important preference, followed by health and nutrition. Less than 5% of the total population ranked mood as the



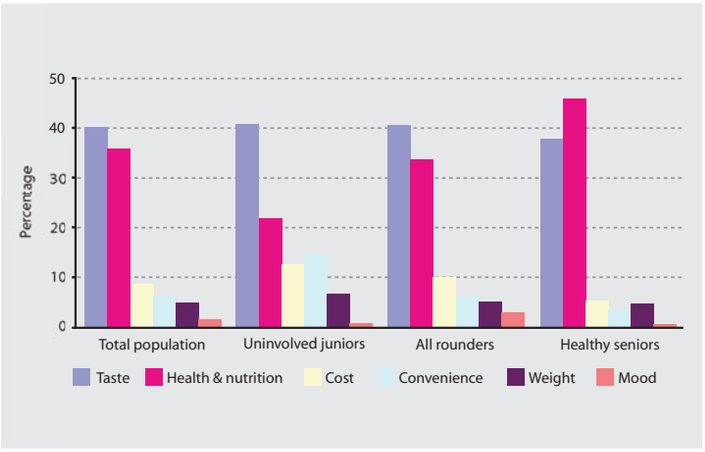


FIGURE 1: Percentage of food preferences ranked first across segments.

most important preference when making food choices. Across the segments, taste was ranked as the most important food preference for 41% of both the uninvolved juniors and the all rounder segments and second highest for the healthy seniors, at 38% of this segment. The high importance of taste has been consistently demonstrated in many previous studies. Taste is the single most significant food preference and is often reason enough for rejection of a food. It is interesting to note that 46% of the healthy seniors segment ranked health and nutrition as the most important, much higher than taste, showing that while they want both from their food, health takes priority. The uninvolved juniors ranked convenience and cost higher and health and nutrition lower relative to the other two segments. Only a small proportion of consumers deemed weight or mood to be the most important preference when making food choices. These segmentation findings illustrate that differences within segments for food choices exist and are different from that of the population overall, showing subtle but significant changes in preferences.

Only a small proportion of consumers deemed weight or mood to be the most important preference when making food choices.

Targeting segments

Healthy eating and healthy lifestyle programmes such as policy or food actions to influence a change in eating and lifestyle behaviour need to be targeted and tailored to the segment characteristics. In particular the 'uninvolved juniors' may warrant particular attention because this group, which is predominantly younger and male, is displaying unhealthy characteristics and ambivalence to the health consequences of their food choices. In terms of Government policy, the younger men need targeted interventions that will encourage and assist them to engage in behavioural change regarding their current health-related attitudes and set them on a healthier food choice trajectory.

From these findings, it is clear that any new food product development (NPD) to offer healthier food options must take account of the importance that is placed on taste. In addition, the different priorities of each segment should be adequately addressed in both marketing strategies and NPD where convenience is an important driver for the younger segments, while health is the dominant priority for older consumers. Additional analyses are currently underway on these data where the segments are being profiled further in relation to food consumption patterns, body measurements and lifestyle characteristics. The research will identify if there are any disparities between the food and lifestyle attitudes of the consumers and their actual food behaviour.

Acknowledgements

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T Events

2012

Dublin City of Science 2012

Dublin has been chosen to host Europe's largest science conference, ESOF 2012 (Euroscience Open Forum), from July 11-15, 2012. To celebrate this prestigious international event, City of Science 2012, a programme of science-related events and activities, will run throughout the year across the island of Ireland. Teagasc will be running a series of events during 2012 in support of City of Science 2012. www.teagasc.ie/research/cityofscience

City of Science/Teagasc events

July 12-13 *Dublin*

A Harvest of Irish Food

July 14 *Convention Centre, Dublin*

A Climate for Change: The great debate on the battle to feed a changing planet

July TBC *Dublin*

Is milk nature's most complete food?

Expert talks and discussion on the benefits of milk beyond nutrition.

JANUARY

January 19 *Lyrath Estate Hotel, Kilkenny*

National Economics Conference

The outlook for the dairy, beef, sheep, pigs and crops sectors in 2012 will be critical to making informed planning decisions for the short to medium term. With this in mind, the conference will include detailed financial analysis for each enterprise and there will be a special session on CAP Reform. www.teagasc.ie/events/2012/20121213.asp

January 25 *Lyrath Hotel, Kilkenny*

National Tillage Conference – Meeting future food demand

The Conference will outline the future European and global food demands, put forward a new business model and address the most pressing agronomic issues for Irish tillage farmers. All are welcome. www.teagasc.ie/events

FEBRUARY

February 7-9 *Teagasc Food Research Centre, Ashtown, Dublin*

Advancing Beef Safety and Quality through Research and Innovation

An international scientific conference and stakeholder demonstration event organised under the aegis of the Sixth Framework Programme-funded project – ProsafeBeef. http://www.prosafebeef.eu/dublin_2012.asp

February 23-24 *RDS, Dublin*

Price Volatility and Farm Income Stabilisation. Modelling Outcomes and Assessing Market- and Policy-Based Responses

An international seminar on policy modelling organised by Teagasc and the Agricultural Economics Society of Ireland under the auspices of the European Association of Agricultural Economists (EAAE). This event will be of interest to researchers, policy makers and other key stakeholders in the agri-food sector. http://www.aesi.ie/eaae2012/index.htm eaae2012@aesi.ie

MARCH

March 12-16 *Teagasc colleges*

Farm Walk and Talk

Organised by Teagasc in association with Agri Aware.

March 12-13 *Tullamore Court Hotel, Tullamore, Co. Offaly*

Agricultural Research Forum

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

March 13, 20-23 *Clonakilty, Mountbellew, Pallaskenry and Gurteen Agricultural Colleges, College of Amenity Horticulture, National Botanic Gardens, Ballyhaise Agricultural College, and Kildalton Agricultural & Horticultural College*

Teagasc college open days

Career guidance teachers and students will have a unique opportunity to get fully updated on all new courses at these special careers events, organised by Teagasc. As well as hearing the full story on all new courses in agriculture, horticulture, horses and forestry, they will also receive information on the diverse range of career opportunities available to graduates. www.teagasc.ie

March 23 *Teagasc Food Research Centre, Ashtown, Dublin*

Teagasc Food Technology Expo

Current Teagasc technologies will be demonstrated to the Irish food industry with a view to commercialisation. Teagasc food industry services, expertise and collaborative research opportunities will also be presented as part of this innovation and technology showcase. www.teagasc.ie/events

APRIL

April 25-26

NutraMara – Bioactive components from marine sources and by-product utilisation and valorisation

This two-day Conference will focus on marine bioresources and will bring together researchers, policy makers, and industry participants. There will be a special focus on marine by-product utilisation and valorisation, with national and international speakers.

MAY

May 28 to June 1 *Rochestown Park Hotel, Cork*

ICAR (International Committee for Animal Recording) 2012 Conference

International conference organised by ICAR and sponsored by Teagasc, the ICBF, the Department of Agriculture, Food and the Marine, the *Irish Farmers Journal*, FBD Trust and Sheep Ireland. http://www.icar2012.ie/index.php

JUNE

June 26-29 *Wexford Opera House, Wexford*

New Horizon: 17th International Nitrogen Workshop – Innovations for Sustainable Use of Nitrogen Resources

The 17th International Nitrogen Workshop will focus on iNNovations, with a capital N, for sustainable use of nitrogen resources: new breakthroughs in science, new breakthroughs in knowledge transfer, and new breakthroughs in management of nitrogen resources. We need innovative solutions to meet the challenges of 2050, and this workshop, which is jointly organised by Teagasc and AFBI (Northern Ireland), will provide the platform to discuss the challenges and solutions. www.nitrogenworkshop.com

June 30 *Teagasc Animal Production and Grassland Research Centre, Mellows Campus, Athenry, Co. Galway*

Sheep 2012

This major event is being organised jointly by Teagasc, UCD, Bord Bia, Sheep Ireland and the *Irish Farmers Journal*, and will build on a very successful open day – Sheep 2010. A new Sheep Research and Knowledge Transfer Programme was recently launched and as part of this programme a new Sheep Research Demonstration Farm of 350 breeding ewes has been set up at Teagasc Athenry, and the new flock will be on display at this event. sheep2012@teagasc.ie