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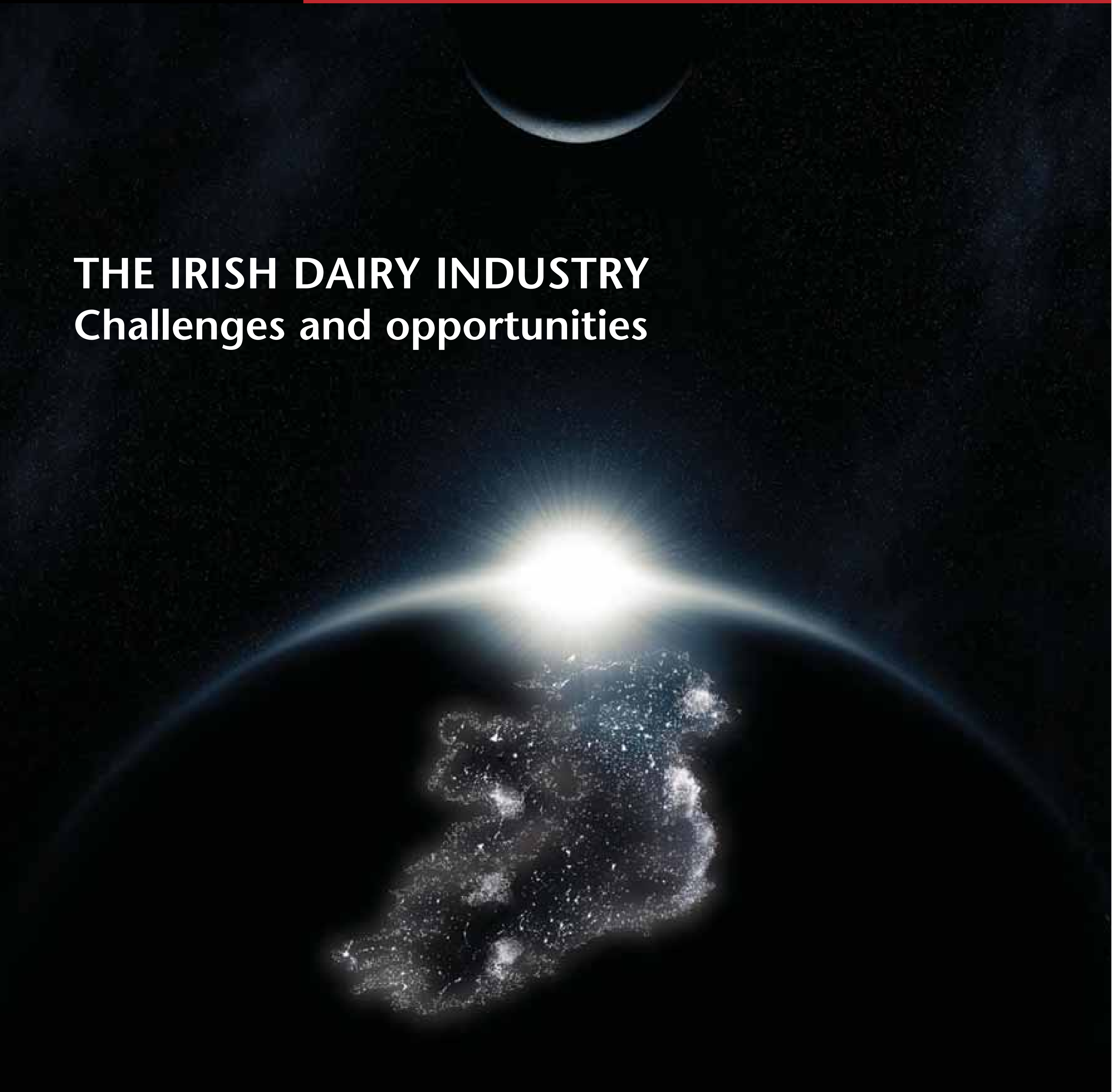
T Research

Research and innovation news at Teagasc



THE IRISH DAIRY INDUSTRY
Challenges and opportunities

Volume 4: Number 2. Summer 2009

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Agriculture and Food Development Authority

National Development Plan 2007 - 2013

TResearch
Teagasc | Oak Park | Carlow

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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AFBI and Teagasc sign scientific collaboration agreement

Scientific collaboration between the Agri-Food and Biosciences Institute (AFBI) and Teagasc has been formally recognised with the signing of a Memorandum of Understanding (MoU) between the two organisations. This MoU will foster opportunities for innovative collaboration among scientific leaders in AFBI and Teagasc.

Both organisations wish to encourage substantial research co-operation in some or all of the fields of animal health and disease control, animal and crop production, climate change, renewable energies, grass breeding and utilisation, food safety and agricultural economics; all research being for the mutual benefit of the island of Ireland.

The MoU will provide opportunities for the exchange of scientific staff to carry out joint research and/or to organise and attend scientific meetings, with a view to promoting the development of co-operative research.

Speaking at the signing of the Memorandum, Seán Hogan, chair of AFBI said: "AFBI and Teagasc have an excellent working relationship, collaborating on Stimulus-funded research projects and through the Teagasc Walsh Fellowships programme".

Dr Frank O'Mara, Acting Director of Agriculture Research in Teagasc, said: "This Memorandum will deepen the relationship between the two organisations, helping to pool our collective resources and create critical mass in a number of research areas of interest and relevance to farmers and the agriculture sector".

Teagasc research highlights

The following are some highlights of Teagasc research activities and initiatives since the start of the year aimed at supporting science-based innovation in the agri-food sector and wider bio-economy so as to underpin profitability, competitiveness and sustainability:

- 65 new refereed papers and 193 other articles were published by Teagasc researchers and their collaborators;
- a new 120 suckler cow calf to beef research and demonstration farm has been established at our Grange Research Centre;
- in collaboration with our colleagues in the Advisory Service and our industry partners we have initiated the BETTER Farm Beef programme on 15 farms across the country;
- a new Dairy Degree Programme with University College Dublin has been launched in collaboration with our colleagues in the Education Service;
- a European first, a new innovative National Cattle Breeding Programme with the Irish Cattle Breeders Federation, incorporating genomic technologies, was launched;
- an international conference on meat safety, attended by representatives from over 30 countries, was hosted;
- Teagasc was invited to present a paper on 'Meat Science and Knowledge Transfer' to European meat executives in Berlin;
- Teagasc has recently received funding from Enterprise Ireland to develop a strategic approach to EU Framework Programme 7 (FP7) involvement;
- Teagasc currently has 11 applications under review as part of the FP7 Food, Agriculture, Fisheries and Biotechnology Programme; and,
- in keeping with our commitment to linking with industry we and our partners have submitted two applications for the industry-led research programmes funded by Enterprise Ireland.

Researcher profile

Dr John Murphy

Dr John Murphy, MSc, PhD, is a Principal Research Officer at the Dairy Production Department at Teagasc, Moorepark Dairy Production Research Centre, Fermoy, Co Cork.

John obtained his BSc in Honours Biochemistry, his MSc and his PhD from University College Cork/National University of Ireland. From 1975 to 1978, he worked as a Research Officer at The Agricultural Research Institute, Dairy Chemistry Department, Moorepark, Fermoy, Co Cork. He moved to the Dairy Husbandry Department in 1978, and to the Dairy Production Department in 1983 as a Senior Research Officer. In 1994, he took up his current position.

John's current research interests include the place of total mixed rations in Irish pasture-based milk production, potential mitigation strategies to reduce methane production by dairy cows, and factors within milk production systems that influence nitrogen leaching and water quality.

He is project leader of three Dairy Levy-funded research projects, and co-ordinator of two projects funded under the Department of Agriculture, Fisheries and Food Stimulus funding programme. He is a collaborator on other projects involving researchers in the Dairy Production Department, in other Teagasc centres, in UCD and in research centres in other countries.

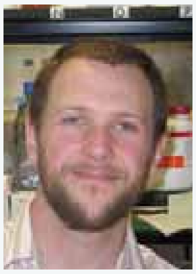
He has travelled worldwide as a visiting scientist and spent periods at the University of Alberta, Canada and at the INRA research centre, St Gilles, France.

He is a co-supervisor of postgraduate students to Masters and PhD level and has been an external examiner for PhD theses in Australia and the UK. He is a member of the Irish Grassland and Animal Production Association, and of the Institute of Biology of Ireland.

He is the author or co-author of approximately 80 scientific papers and 60 abstracts in peer-reviewed journals, and approximately 170 contributions to scientific conferences. He is also the author of a large number of technical contributions in the popular press.

John has presented numerous invited lectures in Ireland and abroad. He is an editor of the *Irish Journal of Agricultural and Food Research*, and is on the organising committee for the annual Agricultural Research Forum.

T News



EUCARPIA

Dan Milbourne has been appointed Chairman of the Potato Section of EUCARPIA, the European Association for Research on Plant Breeding. With a membership of over 1,000, EUCARPIA is the largest organisation representing plant breeders and scientists in Europe. For more see: www.eucarpia.org.

IPSAM win

Kerstin Diekmann, a Walsh Fellow based at Oak Park Crops Research Centre, recently won a prize for best presentation at the Irish Plant Scientist's Association Meeting. The topic of her talk was: 'Diversification patterns of chloroplast genes and genomes in the grasses (Poaceae)'.

Seed vault

Pictured at the launch of an official deposit of Irish agriculture seeds to the recently opened Svalbard Global Seed Vault in Norway were: Professor Jimmy Burke of Teagasc, Norwegian Ambassador to Ireland, His Excellency Mr Øyvind Nordsletten and Minister of State, Trevor Sargent, TD.

The Irish deposit consists of some of the most important seeds in the reference collections of Teagasc and the Department of Agriculture, Fisheries and Food. Almost two-thirds of a million seeds, representing unique accessions of Ireland's forage grasses, potatoes, wheat, oats and barley collections will be deposited at Svalbard as part of Ireland's international commitment to maintain a broad genetic resource base for future needs.

Dual conferring

Professor Paul Ross and his wife Dr Catherine Stanton have become the first couple to be conferred simultaneously with a Doctorate of Science from the National University of Ireland. Paul is Head of Department and Catherine is a Principal Research Officer in the Biotechnology Department, Teagasc Moorepark Food Research Centre.

Accolade for AFRC researcher

Dr Juan Valverde, Ashtown Food Research Centre, has been awarded the Silver Medal of the French Academy of Agriculture by the French Academy of Agriculture for his PhD work, conducted at the College de France/AgroParisTech between 2005 and 2008. His research was a study of the modifications induced by various culinary and industrial treatments of pigment systems from immature pods of green beans (*Phaseolus vulgaris L.*) and the introduction of new analytical methods for the study of these systems.

Teagasc launches innovative SIS

An innovative and landmark Irish Soil Information System (ISIS) was recently launched at Teagasc Head Office in Oak Park, Carlow. ISIS combines cutting-edge spatial mapping technology and conservative ground-truthing (i.e., digging into the soil) and will, for the first time ever, be applied at national scale. The system has previously been piloted successfully at small regional scales in other countries. Teagasc's predecessor, An Foras Talúntais, was almost exclusively responsible for the first soil survey in the '70s and '80s. At the time it took over 15 years and several researchers and field technicians to map the soils of approximately half of the country. ISIS will now seek to map the remaining half of the country within five years by generating knowledge-based predictive soil maps using digital terrain data, subsoil maps and other geo-spatial layers in an advanced Geographical Information System (GIS) technology platform. It will then proceed to calibrate and verify these models through an intensive two-year traditional field sampling campaign; this campaign will provide hard soils data on 300 new reference profiles and over 3,000 auger points across the country.

Wellcome Trust fellowships

Two Teagasc Walsh Fellows in the Animal Bioscience Centre (Aideen Killeen (left) and Aran O'Loughlin (right)) were recently successful in obtaining Wellcome Trust scholarships to participate in molecular biology courses at Cambridge University. They are pictured here with their Teagasc supervisors, Dr Sinead Waters (middle left) and Dr Bernadette Earley (middle right).

Visiting scientist

Professor Jimmy Burke, Head of Oak Park Crops Research Centre (left) with Professor C.S. Prakash, University of Tuskegee, USA, who gave a seminar on 'Communicating AgBiotech Issues to Stakeholders' to researchers at the Centre.

Cutting edge science at the Agricultural Research Forum

Plenary speakers at the Agricultural Research Forum 2009 are pictured (from left): Trevor Donnellan, Rural Economy Research Centre ('Greenhouse gas reduction targets: An economic assessment of the challenges for Irish agriculture'); Bryan Griffiths, Stokes Professor at Johnstown Castle Environment Research Centre ('The application of soil microbial ecology to understanding environmental issues in Irish agriculture'); and, Donagh Berry, Moorepark Dairy Production Research Centre ('The role of systems biology in animal breeding').
The event featured a total of 151 research papers from research institutions all over the island of Ireland. The proceedings are available for download at: www.agresearchforum.com.

General surveillance for GM crops

The European Union has decided that approved genetically modified (GM) crops should be submitted to post-market monitoring. This would be mandatory according to EU Directive 2001/18/EC. The challenge to developing a surveillance scheme is that it should be able to detect unexpected effects not necessarily linked to the GM trait. At a recent workshop organised by the National Institute for Public Health and the Environment (RIVM) in the Netherlands, Professor Bryan Griffiths (Johnstown Castle) joined experts from Germany, Switzerland, the UK and the Netherlands to formulate conclusions and recommendations for the surveillance of GM effects on the soil ecosystem. The Netherlands has the advantage that it already has a soil-based monitoring scheme in operation. Soil quality is monitored on 200 representative farms across the country on a five-year cycle, while there are volunteer networks that monitor selected flora and fauna from thousands of sites on a more regular basis. They could form the basis of a surveillance scheme to start straight away, but it was emphasised that emerging technologies may offer the potential for more comprehensive surveillance in the future. These would include GIS-based satellite imaging and the use of DNA/RNA based microarrays (the so-called geochip) and high-throughput sequencing.
Contact Bryan Griffiths (bryan.griffiths@teagasc.ie) for further information and details.

The Teagasc Change Programme

In the current economic climate, the only certain thing is change. LANCE O'BRIEN describes how the organisation is responding to the challenge through the Teagasc Change Programme 2009-2013.

Research and knowledge transfer – key to economic recovery

The agri-food sector accounts for over half of Ireland's indigenous exports and represents one-tenth of the Irish economy. The agri-food and wider bio-economy contribute an estimated 30% of total national net exports. The sector is also central to the economic and social vitality of rural communities.

Unlike many other sectors of the economy, the long-term outlook for agricultural commodity markets is positive and Ireland is ideally placed to exploit these market opportunities. In particular, in relation to milk production, Ireland is leading Europe in terms of cost competitiveness, and major capacity exists to increase production once quotas have been removed. The dairy sector could play a key role in re-invigorating the Irish economy. In addition, Ireland could build new economic activities in newly emerging sectors such as bio-energy, bio-fibre and bio-pharma. Another dynamic element will be high-value-added processing in areas such as infant foods, functional foods and nutraceuticals.

Policymakers globally are realising the importance of agriculture and natural resources generally in providing solutions to many of the key problems facing mankind, including global food and energy security and climate change. The importance of the sector is recognised in the Government's framework document for economic renewal, 'Building Ireland's Smart Economy', which states that the overall sustainable approach to economic development outlined in the document "complements the core strength of our economy in the use of natural resources in the agriculture, forestry, fisheries, tourism and energy sectors".

Research and development and innovation are essential prerequisites in underpinning the profitability, competitiveness and sustainability of this nationally important sector. The industry must also meet growing public good and service objectives in terms of enhanced food safety, improved natural resource management, biodiversity protection, climate change mitigation and energy security. These challenges will require the agri-food sector of the future to become more fully integrated into the 'knowledge economy'.

Teagasc's critical role

The Teagasc mission is to support science-based innovation in the agri-food sector and wider bio-economy that will underpin profitability, competitiveness and sustainability.

The combination of research and innovation support in one organisation uniquely positions Teagasc to ensure knowledge transfer and to deliver value for money invested. The organisational structure facilitates Teagasc to not only generate/procure the appropriate knowledge, but also to transfer the knowledge through its extensive advisory service and create the capacity within the community to use this knowledge through focused educational programmes. A renewed emphasis on innovation aims to ensure that the knowledge is used in rural areas to create sustainable wealth.

Teagasc's strategic actions are in line with national objectives for the agri-food sector as set out in the 'National Development Plan 2007-2013', 'Agri-Vision 2015' and the Department of Agriculture, Fisheries and Food's 'Statement of Strategy 2008-2010'. The organisation's overall strategy is consistent with Government plans for the development of the knowledge economy and the continuing demands for public service modernisation. Its activities are fully consistent with, and support, the aims of the recently published 'Building Ireland's Smart Economy'.

A commitment to change and adaptation

Teagasc continually develops its responsive programme of knowledge management activities, in conjunction with its clients and partners, overseen by an Authority that is representative of the main stakeholder groups in the agri-food sector. The organisation has recently completed a wide-ranging Foresight analysis ('Teagasc 2030') that focused not only on the challenges facing the agri-food and bio-sector over the next quarter of a century, but also addressed how Teagasc itself will have to adapt to meet these needs. The report identified, in consultation with stakeholders, a clear vision for the long-term future of the agri-food sector and for Teagasc's supporting role. This new role will, of necessity, involve considerable change to the organisation's business model. This ongoing commitment to change and adaptation has been given additional impetus by a new set of challenges arising from 2009 budgetary cutbacks and the prospect of further resource adjustments over the next number of years. In response, the Teagasc Authority approved a new medium-term change programme at its March meeting, which is designed to maintain priority programmes and implement the Vision programme, while achieving efficiencies in the employment of current resources, including the introduction of a voluntary early retirement (VER) scheme. While the plan envisages significant reductions in human and physical resources, it also presupposes that Teagasc, in line with the Government's priority for investment in science, technology and innovation (STI), would be enabled to engage in a focused recruitment programme, upgrade physical resources, reorganise management and programme structures and address critical new and ongoing priorities. However, in light of the recent Government decision preventing the filling, through external recruitment, of public service posts, including contract posts, it would seem as if Teagasc will, in the short term, be unable to engage in the type of focused recruitment envisaged. This latest restriction has significant implications for our overall change programme and will require innovative solutions to enable us to deliver on priority programmes.

A vision for the future

The key implication for the strategic direction of Teagasc arising from the Change Programme is that we will be required to pursue an agenda of activities that is absolutely focused on the priorities of our stakeholders as they are likely to evolve over the next five years. We also commit to use the resources available in the most effective and efficient manner possible in the pursuit of these priorities. While our current work programme addresses many of the emerging priorities, we need to accommodate major new challenges over the next few years. These include the absolute requirement to focus on the utilisation of cost-saving strategies in primary agriculture in the light of prospective changes in the level and volatility of commodity prices. Overcoming the challenges confronting commercial agriculture in the face of climate change and key EU environmental directives, including the Water Framework Directive, will require additional resources.

In both agriculture and food research, we need to aggressively pursue the opportunities presented by the exploitation of the biosciences. These include accelerated animal and crop breeding programmes and the development of functional foods in support of the national policy on foreign direct investment. In rural development, we need to prioritise on-farm/off-farm diversification to combat the much reduced employment opportunities that are likely to prevail off-farm. Above all, we must ensure that over the planning period we strengthen our knowledge transfer function in both agriculture and food.

Implementing the Change Programme

Bringing about change in an organisation is a difficult task. Best practice dictates that the task be approached by way of project management involving a clearly defined project with clear objectives, tasks, deliverables and milestones. It is proposed that the Teagasc Change Programme, under the leadership of a high-level steering group, will involve the following four pillars:

Pillar 1: Resource rationalisation

The first step is the implementation of a balanced rationalisation plan designed to achieve significant efficiencies while maintaining priority programmes.

Pillar 2: People and leadership (PL) strategy

Successful implementation of the Change Programme will require human resource reform, such as removing barriers that restrict movement of professional staff between areas and programmes. The current Teagasc HR Strategy envisages a common entry professional grade and cross-stream access to professional posts on a competency basis, regardless of an individual's current categorisation.

Pillar 3: Organisational structure

The delivery of the Teagasc mission requires quality leadership that will deliver excellence in the performance of each function and which will crucially ensure that each function, both individually and collectively, responds with agility and relevance to the needs of our client sectors. Far-reaching structural changes are needed to achieve the agility and depth of responsiveness that are required. In particular, the effective operation of the three key functions of knowledge creation and procurement, knowledge transfer and knowledge absorption require change in the nature and focus of our current system of directorates.

Pillar 4: Programme integration

The current management structure emphasises the separateness of the different functions of research, advice and education. Integration of functions only comes about in this model on an ad hoc *basis or through personal relationships between staff from different functions. Any new structure must bring about greater functional integration, greater effectiveness in programme delivery and also greater efficiency. The functions of research, advice and training exist to serve the achievement of the goals of the organisation. Our goals should drive the development of our key functional areas, rather than the other way round. 'Teagasc 2030' identified the establishment of programme areas around our key goals as being the mechanism for achieving this outcome.*

The future

Over the next five years we need to tailor our organisation to meet the needs of our stakeholders more directly, applying our knowledge and capacities to respond to their priorities. This process of greater engagement and commitment to address broad challenges will, of necessity, reshape the nature of our programmes and how we organise ourselves to deliver those programmes.

The guiding principles for the future Teagasc must be in maintaining a critical mass of world-class scientific personnel in disciplines critical to Ireland's unique needs, supporting this with necessary levels of research programme funding, utilising the talents of skilled personnel to drive an innovation agenda and ensuring that discoveries are supported with knowledge transfer, technology commercialisation expertise and industry partnerships. The aim must be to fully utilise the unique integrated nature of our organisation to build research and innovation excellence with a spirit of collaboration, encompassing global networks and links with entrepreneurial skills and providing leadership in key areas of the agri-food sector.

'Teagasc 2030' envisions the agri-food sector and the wider bio-economy as becoming a key player in the development of the economy against a background of global food and energy scarcity. The development and transfer of usable knowledge capital is essential to realising this vision. Teagasc's role is to help and support the realisation of this vision by Ireland's farmers and food processors.

Reference

Teagasc. (2009). 'Supporting the Agri-Food Sector in Challenging Times. The Teagasc Change Programme 2009-2013.' Teagasc, March 2009.

Lance O'Brien is Head of Foresight & Strategy Development, based at Teagasc Head Office. E-mail: lance.obrien@teagasc.ie.

The Agricultural Catchments Programme – innovation for farming and the environment

The Agricultural Catchments Programme is based on a partnership with farmers and other stakeholders, and aims to support productive agriculture while protecting water quality, write GER SHORTLE, PHIL JORDAN and REAMONN FEALY.

Aerial view of Castledockerell catchment in Co. Wexford.

"We have not inherited the world from our forefathers; we have borrowed it from our children" – ancient Kashmiri proverb.

The Agricultural Catchments Programme aims to support farmers in handing on economically and environmentally sustainable farms to their children. It will do this through partnership, innovation and integration of Teagasc's strengths in research and technology transfer. A team of researchers and advisers is working closely with farmers to carry out research at catchment scale and facilitate the sharing of information and experience, thus speeding up knowledge dissemination and maximising its impact. This new model has potential applications across the whole farming sector.

Why now?

Achieving economic and environmental sustainability for Irish farming is essential and has never been more urgent. Agriculture and food is an indigenous Irish sector that accounts for 6.3% of GDP, 8.2% of employment and 10.5% of total exports. It is crucial that Ireland maintains a strong farming sector that can grasp opportunities to increase production, while protecting and improving the environment.

The Nitrates and Water Framework Directives are the main environmental drivers of the Agricultural Catchments Programme. The Nitrates Directive (ND) aims to minimise nutrient losses to water bodies from agriculture and is based on managing the rate, timing and accumulation of nutrients to avoid excessive or untimely transfer to water. Statutory Instrument No. 101 of 2009 – Good Agricultural Practice (GAP) for Protection of Waters Regulations – puts Ireland's National Action Programme (NAP) into law. These regulations cover a range of farm practices including limits on nitrogen and phosphorus applications, closed fertiliser spreading periods, manure storage requirements and restrictions on winter ploughing. These measures cover the whole country, with only minor variations from region to region. The Water Framework Directive (WFD) combines a range of EU water directives, including the ND, and includes chemical and ecological standards. Implementation will be regionalised under the WFD using the River Basin District Management Plans, which may have specific measures tailored to each district. In addition to surface waters and groundwater covered by the ND, the WFD includes transitional and coastal waters, and under it all water bodies and groundwater-dependent terrestrial ecosystems must reach "good ecological status" by 2015, or at least be managed so as to move towards that status.

Why a catchment programme?

The ND requires EU Member States to monitor and evaluate the effectiveness of their action programmes and this programme helps to fulfil Ireland's obligation in this regard. The catchments' scale, at five to 11 square kilometres, provides a real representation of farming being carried on in catchments with other non-agricultural nutrient sources and buffering capacities. The catchment scale also offers opportunities to scale up policies to larger catchments or national scale; this would not be feasible using field or plot scale studies.

The Programme approach

The Programme integrates intensive advice with cutting-edge catchment science in an innovative approach to knowledge transfer. Farmer involvement is essential and DAFF has set up a consultation and implementation group (CIG) to facilitate this at national level. At local level, the programme adviser is the main contact with farmers. The adviser's role is to support the farmers in carrying on a viable farm business while protecting the environment. This means facilitating the implementation of the GAP measures while working towards high profit levels. Each adviser covers two catchments dealing with approximately 40 farmers, and uses individual and group contact with farmers to facilitate the transfer of information.

The advisers also collect economic and physical data on the farms, which will be used to analyse any impacts of changes in farm practices in the catchments. Each adviser works with a technician, whose primary role will be data collection and maintenance of instrumentation in the catchments.

The major scientific challenge for the programme is to provide evidence to evaluate the GAP measures. The Programme research team has developed research protocols to do this. They will look at nitrogen and phosphorus sources in the catchments and how they are linked with the supply of nutrients available for transport and loss to water and the movement of water through the soil pathways from farms to receiving waters in the catchments.

The researchers will analyse and model the data to look for links between changes in agricultural practices and indicators of change in the catchments. To facilitate this work, instrumentation is being installed in the catchments to measure quality and quantity of surface and ground water and weather data.

Selecting catchments

The selection of catchments was influenced by EU guidelines, which suggest that monitoring efforts should be concentrated in "areas of intensive crop and livestock production … with elevated nitrate concentrations ... adjacent to existing or projected eutrophication areas … with similar land use, soil type or agricultural practice".

Using these guidelines the Teagasc Spatial Analysis Unit developed a new Geographic Information System (GIS) based selection methodology for the programme. National catchment data provided by the EPA was used to generate a list of 1,300 catchments to select from. A range of data covering land use, livestock density, housing density, geology, soils, and nutrient loss risk was used in a multi-criteria decision analysis (MCDA) approach. Selection criteria were given weightings that reflected their relative impact on the catchments' suitability for inclusion in the programme.

Farmed area was maximised within two broad categories of catchments, grassland and tillage. Stocking rate and forage area were maximised in selecting the grassland catchments, while for tillage catchments the percentage of arable land was maximised. Across all catchments, housing density, forestry, peat and non-agricultural land use were minimised. Catchments were also ranked by risk of loss of nitrogen or phosphorus to water, based mainly on soil permeability rankings. Shortlists of catchments were drawn up based on the MCDA rankings and these sites were visited to assess their practical suitability in terms of access, availability of services, ease of establishment of monitoring sites and other factors.

Six catchments have been selected using this methodology. Two of these are catchments with a high proportion of tillage; one on free-draining soils where the greatest risk is of nitrogen loss through leaching and one on heavier soils where phosphorus loss through surface run-off is more likely. Of the four grassland sites, one has a high nitrogen loss risk while the others are predominantly at risk of phosphorus loss with varying levels of nitrogen loss risk.

A site on pure limestone geology and dominated by groundwater pathways remains to be selected. The GIS methodology described above was designed for surface water-dominated catchments and so does not suit limestone areas. Wide consultation with experts in the field and existing survey data are being used to help identify suitable sites. This selected site is likely to be west of the Shannon in the extensive karst area of Galway/Mayo and will require substantial on-site investigation to delineate its zone of groundwater contribution.

Objectives

The Programme is funded by the Department of Agriculture, Fisheries and Food (DAFF), which sets broad objectives for it. These objectives have guided the design of the programme and shaped the approach that is being taken.

They are:

- to establish baseline information on agriculture in relation to both the ND and the WFD;
- to provide an evaluation of the GAP measures and the derogation in terms of water quality and farm practices;
- to provide a basis for a scientific review of GAP measures with a view to adopting modifications where necessary;
- to provide better knowledge of the factors that determine farmers' understanding and implementation of the GAP;
- to provide national focal points for technology transfer and education for all stakeholders in relation to diffuse nutrient loss from agriculture to water; and,
- to include monitoring that may be necessary for the purposes of the WFD.

Looking ahead

Farming has shaped the Irish landscape while providing a living for generations of Irish people. The challenge is to protect this environment while maintaining profitable farm businesses. This programme aims to help farmers to meet this challenge in the catchments and across the whole country.

Reference

Schulte, R., ***et al.*** (2009). 'The Water Framework Directive – troubled waters or water under the bridge?' *TResearch* 4 (1): 35-37.

Ger Shortle is Programme Manager, Agricultural Catchment Programme, Teagasc, Johnstown Castle Environment Research Centre. **Professor Phil Jordan** is a Principal Scientist, Agricultural Catchment Programme, Teagasc, Johnstown Castle Environment Research Centre. **Reamonn Fealy** is a Research Officer in the Spatial Analysis Unit, Teagasc, Kinsealy.
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Marine functional foods

MARIA HAYES, AFRC, describes the generation of marine functional foods from under-utilised marine resources and rest-raw materials.

Image courtesy of Bord Bia.

According to the Food and Agricultural Organisation (FAO), global marine fisheries production increases annually, with more than 91 million tonnes of fish and shellfish caught each year. Annual discard from this catch is estimated to be approximately 20 million tonnes (25%). European legislation (EU Council Directive 1999/31/EC, 1999) has set specific targets for the amount of biodegradable municipal waste (BMW) for disposal at landfills. Therefore, this discard represents both an environmental and economic problem for seafood processors. Figures from Bord Iascaigh Mhara (BIM – Irish Sea Fisheries Board) estimate that approximately 63,786 tonnes of marine processing waste are produced nationally.

Rest-raw material

Several studies have examined a new field of research concerned with the exploitation of novel materials derived from marine discard. This discard includes what should really be termed 'rest-raw material'. Rest-raw materials include by-products such as viscera, heads, cut-offs, shell, bones and skin. Rest-raw materials are a rich source of proteins, fish oils and carbohydrates that have the potential to be converted into functional food ingredients through isolation of bioactive peptides from protein sources, chitinoligosaccharides and glycoproteins from carbohydrate sources and the major long chain omega-3 compounds from fish/seaweed oils.

Sea vegetables

Furthermore, the marine environment is a rich source of seaweed or sea vegetables (macroalgae) and close to 150 species from the Protista taxonomies Phaeophyceae (brown), Chlorophyceae (green) and Rhodophyceae (red) are used as foods and for phycocolloid production, including agar, alginate and carrageenan extraction (Zemke-White and Ohno, 1999). A variety of brown and red algal species are themselves accepted as Generally Recognised as Safe (GRAS) in the US, Foods of Specified Health Use (FOSHU) in Japan, and are authorised for consumption as foods in many European countries. For example, the *Porphyra* species, also known as 'nori', is the most widely eaten seaweed worldwide and is used in sushi (Liu *et al.*, 1997). Excluding their nutritional value, seaweeds are known to be a rich source of bioactive components including sulphated polysaccharides, which are not found in land plants and which may have specific functions in ionic regulation.

NutraMara project

The Marine Functional Foods Research Initiative (NutraMara project) is an initiative aimed at providing support to the neglected area of marine functional foods research. Within this initiative, Teagasc Ashtown Food Research Centre (AFRC) is project leader and, additionally, is 'work package two' leader, which is entitled "Bioactive discovery and generation". Key components, and current barriers, to the commercial development of bioactive and other seaweed-based products by the Irish seaweed and marine industry include:

1. lack of detailed knowledge regarding the composition of seaweeds and variability of bioactive components within rest-raw material; and,
2. a lack of reliable methodologies for analysis, extraction and purification of bioactive components from natural resources, and problems with the translation of laboratory techniques into scaled-up economical and continuous processes.

Within the NutraMara Project and Teagasc VISION programme, AFRC is involved in extraction, purification and chemical characterisation of marine fractions from marine discard sources such as fish skins, shell, blood and offal, and from the three types of macroalgae – red, brown and green. Bioassay-guided fractionation techniques are used. Carbohydrates such as chitinoligosaccharides, β-glucans, laminarins, fucoidans and galactans will be extracted and characterised both chemically and for bioactivities. The equipment and facilities available at AFRC to perform this work include HPLC, RP-HPLC, BioFlo 110 New Brunswick fermenters, accelerated solvent extractor (ASE®), Q-TOF-MALDI-MS, ^{13}C ^{1}H NMR, freeze-driers and capillary electrophoresis and processing halls.

Bioassays to determine the heart health benefits (ACE-I-inhibitory assays, antioxidant assays, and anti-thrombotic assays) and the antimicrobial activities of marine fractions are available at AFRC. AFRC research into marine functional foods will look at the following raw materials for generation of bioactive compounds with health benefits:

(1) **Seaweed extracts** have a wide range of biological activities. The two major classes of molecules in seaweeds that have most potential as functional food ingredients are polysaccharides and polyphenolics. Polyphenolics are abundant in seaweeds and have known potent antioxidant and heart health activities.

(2) **Seaweed polysaccharides** are unique, abundant, and cost-effectively isolated. They include laminaran, sulphated galactans, fucans and others. Larger polysaccharides need to be partially hydrolysed through fermentation and hydrolysis techniques for incorporation into foods as functional ingredients. Seaweed polysaccharides have been shown to have heparin-like anticoagulation activity, antiviral, immune-enhancing and anti-cancer activities, cholesterol-lowering activity, lipid-lowering effects, and blood pressure-lowering benefits. Brown seaweeds contain alginates and sulphated fucans and these have often been targeted for isolation because of their attested potent anticoagulant action. A particularly interesting product is hydrolysed alginic acid potassium salt, which has been shown to reduce blood pressure in hypertensive patients by up to 20mmHg over a three-week period at a dosage of 5g per day.

The distribution of sulphated galactans in the thallus of red seaweeds is not well determined and only a few species have been studied to date. Carrageenans are sulphated galactans extracted from seaweeds of the order Gigartinales. The antithrombotic properties of carrageenans are well known. Ulvan is produced by green seaweeds *Ulva* (Chlorophyta). Ulvans are poorly or not degraded by faecal bacteria and therefore could serve as stabilisers and promotors for the binding of growth factors to the high affinity receptors of the cells in the intestinal membrane.

(3) **Chitin, a complex natural and cationic polysaccharide**, is the second most abundant polymer in nature. Chitin is found in the marine environment in crab and shrimp shell offal of the species *Callinectes sapidus* and *Chionoecetes opilio*. Chitin is extracted from crab shell waste using harsh chemical extraction techniques utilising strong acids and bases such as NaOH and HCl, or by the more favoured and less harsh enzymatic methods using chitinolytic enzymes such as chitin deacetylases. The FDA has approved the use of chitosan and chitin as well as chitinoligosaccharides. Chitinoligosaccharides may also act as angiotensin-I-converting enzyme inhibitors and as lipoprotein-cholesterol reduction agents.

(4) **Fish protein from rest-raw materials** may be broken down into smaller fragments using proteolytic enzymes. Protein hydrolysates are currently used in a range of food products including infant formula, formulas for the elderly, protein supplements, beverages (as stabilisers), and confectionery (as flavour enhancers) (Kristinsson and Rasco, 2000; McCarty, 2003). Some fish protein and protein hydrolysates have specific heart health benefits. They contain ACE-I-inhibitory peptides derived from the parent fish protein through fermentation and hydrolysis methods, and have the ability to lower blood pressure through ACE inhibition. They also impart heart health benefits by decreasing the risk of type II diabetes through increasing the availability of bradykinin, and the ability to improve glucose tolerance and insulin sensitivity (Kristinsson and Rasco, 2000; McCarty, 2003). Some fish fermentates are already available. For example, Bonito (sardine fish family) hydrolysate is being sold in North America as a supplement to lower blood pressure. Bonito protein hydrolysis has a recommended daily dosage of only 1.5g per day (Kawasaki *et al.*, 2002).

It is envisaged that the marine research carried out at AFRC as part of the NutraMara Project and VISION programmes will benefit not only marine researchers but also the Irish seaweed and marine sectors.

Marine bioactives, especially antioxidants, can be rendered inactive by reactions with oxygen or other food components under certain processing conditions. For these 'active' components to be effective for health-promoting benefits, they need delivery systems that protect them until they reach the site of action where they will be most beneficial. One strategy is to protect marine bioactives through microencapsulation. Microencapsulation involves creating a thin film made of proteins and carbohydrates to trap bioactives inside. Synthetic polymer-based delivery systems that are often utilised by the biomedical and pharmaceutical sectors are not suitable for food applications that require compounds that are GRAS. Food biopolymers that can be used for the delivery of marine bioactives include protein hydrogels and polymer based particulate systems. In addition, fermented foods such as breads, cheese and yoghurt, as well as marine based foods such as tempeh and fish soups, sauces and pastes, are ideal vehicles for delivery of marine bioactives.

Several marine-derived compounds such as omega-3 fatty acids already have recognisable biological activities and are present on the nutraceutical market both as supplements and as food ingredients. For example, some companies already market speciality health drinks fortified with DHA in Japan. However, there are good prospects for the food industry to avail of other promising marine ingredients such as bioactive peptides, glucosamine, oligosaccharides and pigments following scientific validation of their potential health effects.

The Marine Functional Foods Research Initiative (NutraMara) is supported by funds provided under the Strategy for Science, Technology and Innovation 2006-2013 (SSTI), the Marine Institute and the Food Institutional Research Measure (FIRM), to establish a Marine Functional Foods Research Programme. From the marine perspective, 'Sea Change – A Marine Knowledge, Research and Innovation Strategy for Ireland 2007-2013', presents a strategy that aims to drive the development of the marine sector as a dynamic element of our knowledge economy. The Marine Functional Food Research Initiative (NutraMara) is led by Teagasc Ashtown Food Research Centre (AFRC) under the direction of Declan Troy (Head of AFRC). The initiative consortium members include Teagasc Moorepark Food Research Centre (Teagasc MFRC), University College Cork (UCC), University College Dublin (UCD), NUI Galway (NUIG), University of Limerick (UL), and the University of Ulster Coleraine (UUC).

References

Kawasaki, T., ***et al.*** (2002). 'Antihypertensive effect and safety evaluation of vegetable drink with peptides derived from sardine protein hydrolysates on mild hypertensive, high-normal and normal blood pressure subjects'. *Fukuoka Igaku Zasshi*, 93: 208-218.

Kristinsson, H.G. and Rasco, B.A. (2000). 'Fish protein hydrolysates: production, biochemical and functional properties'. *Critical Reviews in Food Science and Nutrition*, 40: 43-81.

Liu, J.N., ***et al.*** (1997). 'B cell stimulating activity of seaweed extracts'. *International Journal of Immunopharmacology*, 19: 135-142.

McCarty, M.F. (2003). 'ACE inhibition may decrease diabetes risk by boosting the impact of bradykinin on adipocytes'. *Medical Hypothesis*, 60: 779-783.

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New Teagasc initiative for Irish food SMEs

PAT DALY from Teagasc Ashtown Food Research Centre outlines how a new support service for Small and Medium sized food Enterprises (SMEs) will operate from Teagasc.

A key objective of the Irish food industry is to maximise value through post-commodity market-led product innovation. One of the main outcomes of the recent Teagasc Foresight Programme was the decision to establish a Food SME Technology Support Service (TSS), with the aim of transferring usable knowledge to the food sector through collaborative research and development, consultancy and training. Small- to medium-sized food businesses (SMEs) make up over 90% of the approximately 700 food manufacturing companies in Ireland.

The competitive position of SMEs largely depends on their capacity to absorb new knowledge and skills, and convert them into innovative solutions.

Similar percentage figures prevail in most other European countries. These small food companies are located in every county in Ireland and contribute enormously to the local and regional economy in terms of employment, and as a key customer and supplier link in the indigenous food supply chain. The competitive position of SMEs, in particular, largely depends on their capacity to absorb new knowledge and skills and convert them into innovative solutions. The new SME TSS will act as a conduit for the transfer and conversion of knowledge into business benefits. The service will be delivered from a world-class base of food research programmes already established in Teagasc and by experienced food scientists and technologists. It will be delivered in close collaboration with Enterprise Ireland and other state food development agencies. Currently, Teagasc's research outputs and innovation supports are captured most effectively by larger companies with structured R&D departments. This new service will be tailored to the needs of companies that do not have such a developed R&D capacity. It will, therefore, form part of an overall strategy to ensure the widest possible reach for Teagasc's services to food companies.

Challenges

The SME food sector faces particular barriers in embracing and applying new knowledge. These include lack of awareness of existing technologies, access to information, and consumer/market needs, as well as operational skills deficiencies. Furthermore, the Irish food industry is highly fragmented, which contributes to the lack of critical mass in key skills and research capacity. The role of the new service is to reduce these barriers, thus helping SMEs with development potential to acquire the technology and knowledge needed to innovate.

Benefits

The Food SME TSS will contribute to the creation of a more competitive food sector. It will extend the reach of Teagasc's innovation supports to high potential smaller food companies with less developed R&D capability. It will help these companies to achieve higher development ambitions in product quality and innovation, and it will contribute to raising the innovation capability and R&D absorption capacity of these companies. Overall, the programme will serve the national development aim to maximise the potential of the indigenous sector.

Programme

The core elements of the SME support programme are:

New Product Development (NPD) supports for SMEs

A key focus of the service will be to provide NPD through:

- consultancy and advice;
- contract research;
- access to food processing plant services; and,
- specialised analysis and product testing.

NPD supports will be provided, in the main, on a confidential one-to-one basis either at Teagasc centres, or in the food business premises.

Specialist training and consultancy

Training and individual consultancy support is a very effective means for supporting food business. Teagasc will develop and deliver training programmes in innovation management and technology transfer. These core training programmes will include modules on new product development, processing technologies, legislation, food assurance standards, marketing, and business planning skills.

Training programmes will address specific industry needs and skills gaps identified in national studies and in consultation with industry. In addition, businesses can avail of assistance from consultants for their individual development needs.

Information and marketing supports

Understanding consumer and market needs is a critical success factor. A marketing support service will provide information to assist companies in making marketing decisions and develop marketing plans. This service will be provided in conjunction with other organisations and, in particular, with Bord Bia.

Knowledge and experience gives a competitive advantage and Teagasc provides a comprehensive technology information service for food businesses. This will involve information searching, providing access to national and international experts for problem solving and information on emerging technologies, and advice in accessing technology information sources.

Teagasc will put in place a consultation mechanism with industry and other stakeholders to identify the research and development needs of food SMEs. Elements will include: feedback from individual businesses and entrepreneurs, consultations with industry, food sector advisory panels, and industry surveys. Also, through discussions with industry associations and other food sector development agencies and, in particular, with Enterprise Ireland.

Resources: facilities, capabilities and operation

Teagasc resources and expertise extend from farm to fork. Our expertise will address SME needs in products (product development), processes (process technology, management systems, HACCP) and people (skills development). A significant staff resource of about 15 technology support personnel will be devoted specifically to SME support. In addition, the service will be underpinned by the expertise of over 50 food researchers/technologists with extensive research and industry experience. Through these staff, Irish SMEs will benefit from the R&D work of food research institutes worldwide. Food R&D facilities at Teagasc Ashtown Food Research Centre and Teagasc Moorepark Food Research Centre contain a wide range of food processing facilities and equipment. These include pilot and production-scale facilities for dairy product processes, meat and seafood processing and prepared foods. The facilities are regulatory-approved food processing plants and operate to best quality assurance standards. Modern food preparation, food display and sensory testing facilities are available. Well-equipped testing laboratories are available for new product development testing for microbiological (shelf life), chemical (nutritional) and physical parameters. Teagasc will ensure that the service is delivered to best customer service standards and in response to market demands. The service will be provided in the spirit of partnership with the stakeholders and beneficiaries, both in the development and management of the overall service.

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Buttermilk – a 'health blast' from the past!

An age-old dairy by-product could hold the key to the functional food of the future. PHIL KELLY and BRIAN MURRAY from Teagasc Moorepark outline the strides that have been made in mining buttermilk for functional components.

Buttermilk is a by-product of the butter-making process, and consists of the water-soluble phase of cream, which is released during churning when butter is being formed. Buttermilk formed the main part of the staple diet of the Irish peasant population in the 18th and 19th centuries. Domestic buttermilk preparation and consumption declined as industrialisation of milk processing began to take over in the early 1900s; nevertheless, consumption of traditional buttermilk as a beverage was still evident in rural Ireland up to the 1950s. Today, commercially retailed 'cultured buttermilk' is a misnomer and bears no relation to the original product. Cultured buttermilk is usually manufactured by simply fermenting skim milk with a lactic acid-producing culture.

Buttermilk as a dairy beverage

Universally, buttermilk falls into the category of fermented dairy products largely because lactic (sour cream) butter is predominantly made in mainland Europe and elsewhere. Sweet cream butter, on the other hand, is preferred throughout Ireland and the UK and, consequently, the buttermilk by-product is usually collected and processed in non-fermented form.

Buttermilk is similar in composition to skim milk, i.e., the non-fat milk phase that remains after cream separation. Hence, both products share similar protein, lactose, minerals and dry matter contents. A marginally higher residual fat content in the case of buttermilk distinguishes it from skim.

Buttermilk, however, tastes different to skim milk, mainly due to flavour compounds in milk fat released during cream churning. In addition, if milk or cream is soured prior to buttermilk preparation, then fermentation will add to the intensity of a sharp lactic buttermilk flavour. Hence, the drinking of buttermilk may be described as an acquired taste – something that our forebears did not shirk in their day! The nearest equivalent dairy beverages in today's terms are drinking yoghurts and the so-called 'single-shot' probiotic drinks, which are much milder tasting.

The topic of buttermilk as a beverage has been revisited in Moorepark over the past three years. The reason for doing so has been associated with a growing realisation that many of the components released into buttermilk during butter churning are of biological interest. These components, in the first instance, formed part of the natural emulsifying layer (milk fat globule membrane – MFGM) that surrounds the fat globules in milk and are released during emulsion breaking when cream is churned.

Buttermilk and milk fat globule membrane

Milk fat globules are secreted in the mammary cells of the cow by a process of 'budding off' from the surface of the cell. During this process the fat globules are forced out of the cell with part of the cell membrane surrounding them, hence the term MFGM.

MFGM is increasingly recognised as possessing important biological activities and, hence, the growing interest in 'mining' buttermilk to establish the functionality of MFGM components. MFGM consists of a complex mixture of proteins, glycoproteins, enzymes, neutral lipids and polar lipids such as phospho- and sphingolipids. Protein accounts for less than half of the material in the MFGM. The major MFGM proteins include: mucin 1, xanthine oxidase, mucin 15, cluster of differentiation 36, butyrophilin, adipophilin, PAS 6/7 (lactohedrin) and fatty acid binding protein (FABP). Some MFGM proteins, such as breast-ovarian cancer susceptibility protein (BRCA1), are known to inhibit the growth of cancer cells. In addition, MFGM components can adhere to pathogenic microorganisms, thereby preventing their attachment to the mucosal membrane. Xanthine oxidase, an enzyme with broad substrate specificity, is believed to play a role in antimicrobial defence in the neonatal gut. Approximately 40% of the total lipid associated with the MFGM is present as phospholipids. The major and minor phospholipids present in the MFGM are phosphotidylcholine, phosphotidylethanolamine, phosphotidylinositol, phosphotidylserine, sphingomylein, glucosylcerebroside and lactosylcerebroside. Certain sphingolipids influence cellular apoptotic (programmed cell death) pathways and their anti-cancer effects may lead to potential constituents of an anti-cancer regimen, or as health-altering ingredients. Studies on the intestinal digestion and absorption of sphingomylein from milk have identified an alkaline, bile-salt-dependent sphingomyleinase in human bile and intestinal mucosa. The possible biological functions of sphingomylein and its breakdown derivatives as bioactive compounds include participation in cell proliferation and intracellular signalling, and also there is a suggestion that the sphingosine and ceramide formed from dietary sphingomylein digestion, may suppress development of colon cancer.

Fate of MFGM in modern dairy processes

Modern dairy processing practices have been shown to damage or even destroy the MFGM. Retailed pasteurised milk is typically homogenised to prevent creaming in the milk bottle/carton, but the process of homogenisation disrupts MFGM and recreates an alternative emulsifying layer in the newly-formed smaller milk fat globules. The full ramifications for the biological activities of MFGM components arising from processing-induced microstructural changes have yet to be established. Milk and cream preparation in advance of buttermaking involves heating on two occasions, e.g., about 50°C before cream separation, followed by pasteurisation later to 80-90°C. Our work shows that heat treatment of cream above 65°C leads to irreversible changes to the MFGM and results in losses of MFGM material to the lipid phase (butter), as well as reduced biological activity.

By reverting to almost artisanal-style buttermaking practices, we have been able to track changes associated with modern dairy processes to MFGM composition in both creams (prepared for buttermaking) and the resulting buttermilks. Heating of milk and creams results in greater incorporation of both casein and whey protein in MFGM. We have observed loss of some MFGM proteins, most notably PAS 6/7, during washing of creams and this carries through to the resulting buttermilks. Our work is proving that the more highly processed creams result in buttermilks containing reduced MFGM material and, consequently, reduced biological activity.

An additional finding arising from simulating the artisanal practice of souring cream before buttermaking was that fermentation, whether of the ‘wild’ type, or conducted under controlled laboratory conditions, alters MFGM composition and reduces the biological activity.

Enrichment and fractionation of MFGM

In gross compositional terms, the total fat content (<1.0%) broadly defines the content of MFGM in buttermilk, although it is comprised of protein also. As with all ingredient innovation, the desire is to extract the components of interest in an enriched form in order to enhance functionality. Selective separation by crossflow microfiltration (MF) membranes was applied to remove non-MFGM components in buttermilk such as whey proteins, lactose, minerals and water. An unexpected development was significant loss of bioactivity during subsequent spray- or freeze-drying of enriched-MFGM preparations.

Techno-functional potential

Apart from the focus on the biological value of MFGM-enriched extracts from buttermilk, there is additional interest in the potential use of MFGM as a natural emulsifying agent. In this regard, the emulsion stabilising role of the MFGM layer is due to its steric and electrostatic repulsion of fat globules, thereby preventing their aggregation.

Future research into MFGM

This project, which is now nearing the end of its contract, has addressed a number of the questions posed at the outset and raised many others. For example, modern dairy processes appear to compromise the biological functionality of MFGM not alone in preparatory stages of milk processing, but also during preservation of enriched fractions. A significant capability has been put in place at Moorepark in terms of expertise, analytical techniques for the characterisation of MFGM components, and use of novel separation technologies. In addition, collaborative links have been established internationally with the University of Calpoly, USA and INRA, France. MFGM has opened up a new and exciting area in dairy research in order to explore a commercially underdeveloped by-product of milk for potential development as functional beverages or ingredients. What makes the subject so fascinating is that milk’s natural emulsification system acts as a carrier for such a diverse range of functional components. While most of the work up to now has focused on buttermilk, we would also like to examine other dairy processes/product streams where MFGM material prevails.

Some of the buttermilk fractions developed in the course of this work have been successfully incorporated into fermented milk-style beverages using yoghurt as a base material for blending. These adapted beverages have sensory attributes which are more attuned to the tastes of today’s consumers. However, further work is needed to track the carry-through of biological functionality from the ingredient stage to end-product before the full commercial potential can be determined.

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T Crops

Improving detection of barley yellow dwarf virus

How advances in technology development can increase our understanding of barley yellow dwarf virus is explained by JOHN MCDONALD, TOM KENNEDY and GORDON PURVIS.

Barley yellow dwarf virus (BYDV) is a major disease of cereals in Ireland, especially in early autumn and late spring-sown cereal crops. Symptoms of BYDV infection include a bright yellow or orange-red discolouration of the foliage (depending on host species), general stunting and chlorosis. The earlier infection occurs in the cereal crop, the greater the impact on yield. Aphids transmit BYDV and this group of pests is responsible for the transmission of 66% of the known 370 plant viruses that invertebrates spread. BYDV is one of the most widespread and destructive virus diseases of small grain cereals in the world. The dynamics of BYDV in the field involve primary infection, i.e., the introduction of virus by mobile immigrant winged aphids flying into a crop, and secondary spread within the crop by the wingless progeny of the original immigrant aphids. In Europe, three distinct BYDV strains have been characterised by differences in their principal aphid vectors, as well as their pathogenicity and serological properties. The groups are designated on the basis of their principal vectors. Rhopalosiphum padi virus (RPV) is transmitted by *Rhopalosiphum padi* (L.), Macrosiphum avenae virus (MAV) is mostly transmitted by *Sitobion avenae* (Fab.), and padi avenae virus (PAV) is mainly transmitted by *R. padi* and *S. avenae*. The most common strain in Ireland is MAV. BYDV has a wide host range, infecting grasses mainly in the family Poaceae, including the major cultivated small-grained cereals, wheat, barley and oats, maize, and many cultivated and wild grasses.

The study of BYDV in natural systems has been limited by the lack of efficient and sensitive diagnostic techniques. Enzyme linked immunosorbant assay (ELISA), as used at Oak Park, has proven to be a versatile serological method for the detection of BYDV, especially when dealing with large numbers of samples. A major advantage of ELISA is its ability to detect BYDV in air-dried leaves or in plant material kept at room temperature for several days. However, ELISA can lead to false negative results for aphids carrying less than 106 virus particles. Therefore, ELISA cannot be used as an accurate tool to determine whether individual aphids are viruliferous (virus carriers). Neither will it detect sub-clinical BYDV infection in cereal plant tissue.

Molecular methods offer increased sensitivity for virus detection, eliminating the possibilities of false negative results and giving a more accurate picture of the viruliferous state of aphid populations. Monitoring aphid numbers is an important part of BYDV control. However, on their own, aphid population estimates do not give complete information on the virus threat to crops. Monitoring the abundance of viruliferous aphids at an early stage of crop development can lead to improved disease control, since virus can be spread effectively even though aphid numbers and virus pressure are low. Disease symptoms may take several weeks to appear in infected crops and so a sensitive and accurate virus detection test that can identify virus infection in vectors and asymptomatic plants is an invaluable investigative tool with which to study the ecology of BYDV in the field.

In order to improve the detection and diagnosis of MAV-BYDV in Ireland a diagnostic detection method using real time reverse transcription polymerase chain reaction (RT-PCR) technology was developed. The assay was then used to investigate potential aphid and plant sources of BYDV infection. These sources included stubble re-growth, intensively and extensively managed grassland, maize crops and grass field margins.

Molecular markers

Molecular markers for MAV-BYDV were developed targeting conserved regions of the MAV coat protein gene sequence. In addition, markers were also developed for the PAV and RPV strains.

The developed real time RT-PCR MAV detection assay could detect as few as 10 virus particles, indicating that it is a million times more sensitive than the ELISA detection methods for the MAV strain of virus. In addition, aphid and plant viral load concentration could be determined by the construction of a standard curve with MAV viral quantities of known concentrations. For each individual aphid and plant extraction, the concentration of MAV can be determined by reading off the standard curve.

Practical application

The developed diagnostic assay was used to detect and quantify virus in both aphid and plant samples collected from the field in the period 2002 to 2004. In 2002, the first year of the study, extensively managed grassland had the largest proportion of virus-infected aphids followed by volunteers (plant that grows in crop that was not intentionally planted)/stubble re-growth. However,

volunteers/stubble re-growth had the largest aphid population densities and, therefore, represented the greater source of virus infection to newly planted cereal crops. Both of these habitats had a significantly greater proportion of aphids testing positive for MAV virus when compared with intensively managed grassland. Again, in 2003, volunteers/stubble re-growth and extensively managed grassland had significantly greater proportions of infected aphids compared with other sampled habitats. Aphid density was markedly lower in 2004 than for the preceding two seasons, and extensively managed grassland was found to be the greatest source of virus. The latter arose because, while the proportion of virus-infected plants in extensively managed grassland is usually low, the overall number of infected grass plants is generally much greater than that for volunteer cereal plants due to the greater area of grassland.

Maize crops were investigated for the first time as a source of MAV infection in 2004. While relatively large populations of *Rhopalosiphum padi* aphids were found on maize cobs, virus infection levels were low, with only approximately 6% of aphids vectoring the MAV virus. Overall, the investigations showed that plant material from volunteer/stubble re-growth had significantly higher concentrations of virus when compared with plants from other potential reservoirs. Individual cereal volunteer plants from stubbles had approximately 360 times greater MAV virus concentration than maize plants or plants from intensively or extensively managed grasslands.

Therefore, when aphid populations are high volunteer/stubble re-growth is a more important virus source than plants from other habitats since aphids have a distinct preference for cereals over grasses and virus concentrations are greater in volunteer cereal plants. However, a build-up and establishment of virus-infected plants can occur more easily in extensively farmed grassland due to fewer disturbances by animals and machinery, and in seasons of low aphid occurrence this grassland is a reservoir of the virus, enabling it to persist from one season to the next.

Technology application

Using real time RT-PCR technology, it is now possible to screen single aphids for MAV virus. Because of its sensitivity for the detection of BYDV, the developed assay can quantify extremely low levels of the virus in plant and aphid tissue.

One practical application of these developed molecular tools is that they can be used to inform cereal growers of an imminent outbreak of BYDV. By routine plant tissue and aphid sampling and laboratory screening for the disease, the cereal grower can rapidly be informed if significant amounts of plants and aphids are infected with virus. Such rapid diagnosis is important, especially in newly emerged crops when they are at their most vulnerable stage of attack by aphids. In addition, the building of a profile of the most important sources of BYDV infection can provide the knowledge to permit reducing or possibly eliminating the requirement for the routine use of sprays to control BYDV infection, particularly in the case of spring sown crops.

The proportion of viruliferous aphids can be assessed using the developed real time RT-PCR BYDV detection assay. For BYDV spread to occur, a vector must move the virus from the reservoir (cereal volunteers, grasses, maize, etc.) to newly sown crops. Previous investigations of the incidence of BYDV in aphid populations have depended on test methods with limited sensitivity. For this reason, most of the published data concerning frequencies of natural viruliferous aphids are probably underestimates.

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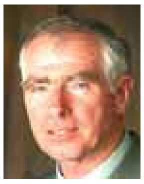

Behavioural response to repeated regrouping and relocation

BERNADETTE EARLEY, Animal Bioscience Centre, Teagasc, Grange, has been investigating the behavioural responses of steers to repeated regrouping and relocation during housing.

Cattle are social animals and ranking within a group occurs based on dominant and submissive behaviour. When cattle are moved from one group to another, a new social order for that group must be established. Mixing of animals from different groups may upset the dominance hierarchy. However, for a variety of management reasons, livestock producers need to regroup and relocate animals. Regrouping and relocation (R & R) of animals occurs as a management practice to create homogenous groups organised by age, weight, production system (milk yield, body condition, reproduction and performance) and health state.

For these reasons, regrouping may occur by mixing animals on one occasion or repeatedly. Negative effects of regrouping on the production performance of sheep have been reported (Sevi *et al.*, 2001). Mixing of familiar animals in the immediate environment of animals, or mixing of unfamiliar animals, is known to cause aggression, increase locomotion behaviour and disrupt social behaviour. Previous studies on R & R have focused on young calves and cows and there is no data available on the response of steers to R & R.

The aim of the present study was to investigate the effect of repeated R & R on behaviour and production performance of finishing steers.

Treatments

Seventy-two Holstein-Friesian steers (14 months old; mean body weight [BW] = 441 ± 3.2kg) were blocked by body weight and assigned to either control (n=30) or regrouped (n=42) treatments. Steers were housed in 12 pens with six steers in each pen at a space allowance of 2.8m^2 per steer. The pens for both treatments were alternated within the shed.

The steers were housed for 84 days in a 12-pen slatted-floor facility with two rows of six pens facing each other. The dimension of each pen was 4.5 x 3.8m with a feed face of 4.5m long. A steel mesh with dimensions of 3.8 x 1.6m separated the sides of each pen. The steers had *ad libitum* access to grass silage and supplemented with 2.5kg of barley/soybean mix concentrate ration. The grass silage had a dry matter (DM) content (mean values) = 224g/kg, *in vitro* DM digestibility = 887g/kg of DM, pH 4.2, and the concentrate ration (mean values) was composed of crude fibre = 41.9g/kg, crude protein = 155g/kg, acid hydrolysable oil = 39g/kg, and ash = 58.6g/kg per animal daily. Steers had free access to water in their pens.

Regrouping and relocation

Regrouped steers were exposed to six R & R events from day 0 to day 84. Following each R & R, new pen cohorts (n=6 steers per pen) were allowed to stabilise for 14 days. In each R & R, none of the regrouped steers were allowed to share the same pen or pen-mates where or with whom they were previously housed. Control steers were housed in the same pen with the same pen-mates for the duration of the study. On the day of R & R, steers from the regrouped treatment were individually taken out from their pens and were regrouped and taken to their new pens. Each R & R of regrouped steers was staggered and was carried out between 8.00am and 8.30am. Immediately after R & R, the housing facility was closed and steers with their new pen cohorts were allowed to interact for two hours without human interference.

Behaviour measurements

CCTV cameras were used to record the behaviour of the steers in each pen. For each pen, behaviour was continuously recorded for seven days and the steers were observed by instantaneous scan sampling. The interval between scans was two minutes for two hours on day one (immediately after R & R), followed by every 20 minutes for the remainder of days one and two. From day three to day seven, each steer was observed every 120 minutes. In the behavioural activity category, steers were observed for lying, standing, eating and drinking behaviour. In the contact behavioural category, steers were observed for no body contact with other steers and contact (head-to-head and head-to-body) with one, two or three steers. The live weight of steers was recorded on day -1 and days 13, 27, 41, 55, 69 and 83, to determine live-weight gain (LWG; kg/day).

Results

R & R of steers resulted in immediate (within two hours) and increased contact behaviour (head-to-head and head-to-body contacts) between the introduced animals and/or the established groups. These behavioural activities continued throughout the initial mixing period, although at lower levels, while the social hierarchy became established. The immediate exposure (within two hours) of steers to unfamiliar animals, after the first, second, third, fourth, fifth and sixth R & R resulted in reduced lying and increased standing behaviour compared with controls (**Table 1**). The percentage time that regrouped steers spent eating was greater at the first, second, third, fourth and sixth R & R compared with controls. The percentage

CCTV cameras were used to record the behaviour of the steers in each pen.

time that regrouped steers spent drinking was greater at the first, third and fourth R & R compared with controls (**Table 1**). During the first day following the first and second R & R events, regrouped steers spent a greater time standing, eating, and drinking, and a shorter time lying compared with controls. Contact behaviours, including head-to-head and head-to-body, were greater in regrouped steers compared with controls. No differences in lying, standing, eating, drinking and contact behaviours were observed among regrouped and control steers on days two to seven after R & R. There was complete adaptation of regrouped steers at the third, fourth, fifth and sixth R & R events. The behavioural changes observed following the third, fourth, fifth and sixth R & R indicated that steers adapted to R & R and spent less time standing and had less threatening contact behaviours (head-to-head and head-to-body) with other steers during the seven-day observation period post regrouping. R & R of steers had no negative effect on live-weight gain.

Conclusion

Steers adapted to situations of repeated R & R with unfamiliar animals by exhibiting less fighting behaviour and faster establishment of social bonds. In the present study, animals displayed more standing behaviour immediately (within two hours) following R & R. However, following repeated R & R events, more lying and less threatening contact behaviours were observed. It is concluded that there was no negative effect of R & R on the behaviour and performance of steers.

Commercial implication

Steers adapt to being regrouped and relocated with unfamiliar animals without detrimental effects on their behaviour and performance.

This research is funded by the National Development Plan.

Reference

Sevi, A., Taibi, L., Albenzio, M., Muscio, A., Dell'Aquila, S. and Napolitano, F. (2001). 'Behavioral, adrenal, immune, and productive responses of lactating ewes to regrouping and relocation'. *Journal of Animal Science* 79: 1457-1465.

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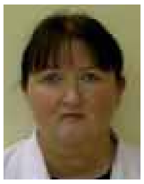


TABLE 1: Behaviour of 72 steers over the first two hours following each R & R (control [C] = 30 steers, regrouped [R] = 42 steers). Behaviour is presented as percentage (%) time in each behavioural category.

Behavioural category	Regrouping and relocation (R & R)[1]											
	1		2		3		4		5		6	
	C	R	C	R	C	R	C	R	C	R	C	R
Lying	33.3	**4.0***	13.3	**5.9***	22.1	**3.2***	40.1*	**6.3***	2.9	**0.2***	61.5	**29.1***
Standing	32.8	**51.8***	38.3	**42.9***	42.7	**51.6***	33.8*	**49.1***	30.5	**34.7***	19.3	**35.8***
Eating	30.1	**38.4***	42.9	**46.2***	31.5	**39.6***	22.5	**37.9***	61.8	59.7	16.3	**31.6***
Drinking	1.8	**3.7***	3.8	4.3	2.6	**4.6***	1.8	**4.7***	3.8	4.5	2.5	3.2

[1]*Regrouped (R) steers were exposed to six R & R events during an 84-day period and each new cohort was allowed to stabilise for 14 days. Control (C) steers were housed in the same pen with the same pen mates throughout the experiment.*
**Significant difference between treatments at each R & R for each behaviour observed (P<0.05).*

T Events

Science Events

May

May 20 — *The Hogan Suite, Croke Park*

Survey Ireland 2009 – 'Geo-informatics in Irish Agriculture'

Teagasc researchers are co-ordinating a session on 'Geo-informatics in Irish Agriculture' featuring the following topics: spatial analysis of agri-policy; farm level mapping; and, use of geospatial technology in Irish agriculture.
stuart.green@teagasc.ie

May 21 — *Hillgrove Hotel, Monaghan*

All Ireland Mushroom Conference and Trade Show – 'Survive and Thrive'

This conference includes a workshop on disease identification and control, and features researchers from Teagasc and AFBI. There will also be sessions on: mushroom research update; spent mushroom compost – 'fertiliser or fuel'; renewable energy – wood and wind options; the market for mushrooms – Ireland and UK; growing to a blueprint – 300 tonnes per week; and, currency volatility. The industry discussion forum panel includes: Ronnie Wilson, Monaghan Mushrooms; Padraig O'Leary, Walsh Mushrooms; Michal Slawski, Bord Bia; Colm Feely, Drimbawn Mushrooms; and, Claire Duffy, Ulster Bank. The conference will be opened by Brendan Smith, TD, Minister for Agriculture, Fisheries and Food. There will also be a trade show and a study visit.
helen.grogan@teagasc.ie *www.teagasc.ie*

June

June 9 — *Moorepark Food Research Centre*

Moorepark Food Research Centre open day – 'Food Innovation in the Knowledge Economy'

Teagasc's Moorepark Food Research Centre is a major public research centre serving the dairy food, ingredients and functional food sectors, and it has been the location for many developments in product and process innovation in recent years. Recently, Teagasc has been up-scaling its investment in functional foods research at Moorepark and, in an open day to celebrate its 20th anniversary, the centre will exhibit the most recent examples of our research in this area, together with the wider research programme encompassing food ingredients, dairy foods and food quality. It also plans to exhibit interactions with industry, for which the Centre has achieved a strong international reputation. Central to these interactions is the pilot plant subsidiary, Moorepark Technology Ltd. A special feature of the open day will be the launch of an important new Teagasc Programme of Technology Support to Food SMEs, manned and operated jointly between Moorepark and Ashtown Research Centres. The guest speakers will be: Professor Frank Gannon, Director General, SFI; and, Stan McCarthy, Chief Executive, Kerry Group plc.
www.teagasc.ie

June 17 — *Kilkenny*

Bioenergy '09

This major showcase event will be presented jointly by Teagasc, COFORD and Sustainable Energy Ireland. The use of wood fuel for energy generation is a new, exciting and growing sustainable industry, with potential for considerable expansion. It offers benefits for forest owners and managers, project developers, consumers, local communities and the environment. Bioenergy '09 will include a conference where leading national and international experts share their experiences and expertise with delegates. It will also be a great opportunity to make contact with exhibitors showcasing their products and services at the Conference. Delegates will be able to experience firsthand the complete wood energy supply chain: from forest to furnace. Participants will have the opportunity to visit a local forest to see forest energy operations including chipping activities in action, while a visit to operational wood chip boilers is also planned. The event will showcase the most recent developments and opportunities in the wood energy sector and raise awareness across all sectors – from landowner to entrepreneur, from forest owner to end use in the domestic, commercial and industrial sectors – on the many uses and benefits to growing, harvesting and using wood fuels and energy crops products to generate heat, electricity and fuel for our homes and businesses.
steven.meyen@teagasc.ie *www.teagasc.ie/forestry*

June 18 — *Teagasc Moorepark, Fermoy, Co. Cork*

Moorepark '09 Open Day – New thinking for challenging times

This, the major Teagasc event of 2009, coincides with a time of low milk prices. There is an urgent requirement to increase efficiency in all aspects of the Irish dairy industry. Moorepark '09 will highlight a new direction for profitable milk production in a volatile milk price environment and the importance of the latest research results to a more sustainable dairy farming and processing industry.
Moorepark '09 is an ideal opportunity to see at first-hand the results of the comprehensive research programme at Moorepark and to meet Teagasc research and advisory staff.
margie.egan@teagasc.ie *www.teagasc.ie*

July

July 1-2 — *Ashtown Food Research Centre*

Legal Labels Ireland – The Essential Guide to Irish Food Labelling

Presentations cover all major labelling considerations, with emphasis placed on more topical and complicated issues such as product-specific labelling for foods with compositional standards, allergens, additive controls and labelling, nutrition and health claims, and the new developments in general food labelling.
www.teagasc.ie

September

September 9-11 — *Teagasc Johnstown Castle, Wexford*

Soil quality: does it equal environmental quality? – International conference

A joint meeting of the British Soil Science Society and the Soil Science Society of Ireland. This conference will address the following issues: What is the significance of soil quality; and, specifically: What can soils do for the wider environment? What are the benefits to the biosphere, agriculture and humanity? What are the threats to soil quality and what is the extent of these threats in Britain and Ireland?
rachel.creamer@teagasc.ie *www.ucd.ie/sssi*

September 21-22 — *Moorepark Food Research Centre*

***Listeria monocytogenes* conference**

With increasing cases of listeriosis in recent years, it is important that the results of a large number of research projects on this subject are disseminated. This conference will be of interest to industry personnel that need to be aware of *L. monocytogenes* and to those working with the organism in a clinical or surveillance setting.
kieran.jordan@teagasc.ie *www.teagasc.ie*

October

October 14 — *Hudson Bay Hotel, Athlone*

Artisan Food/Rural Tourism Conference

www.teagasc.ie

October 15-16 — *Moorepark Dairy Production Research Centre*

International Conference: Forage legumes in temperate pasture-based systems

www.teagasc.ie

November

November 8-15 — *Nationwide*

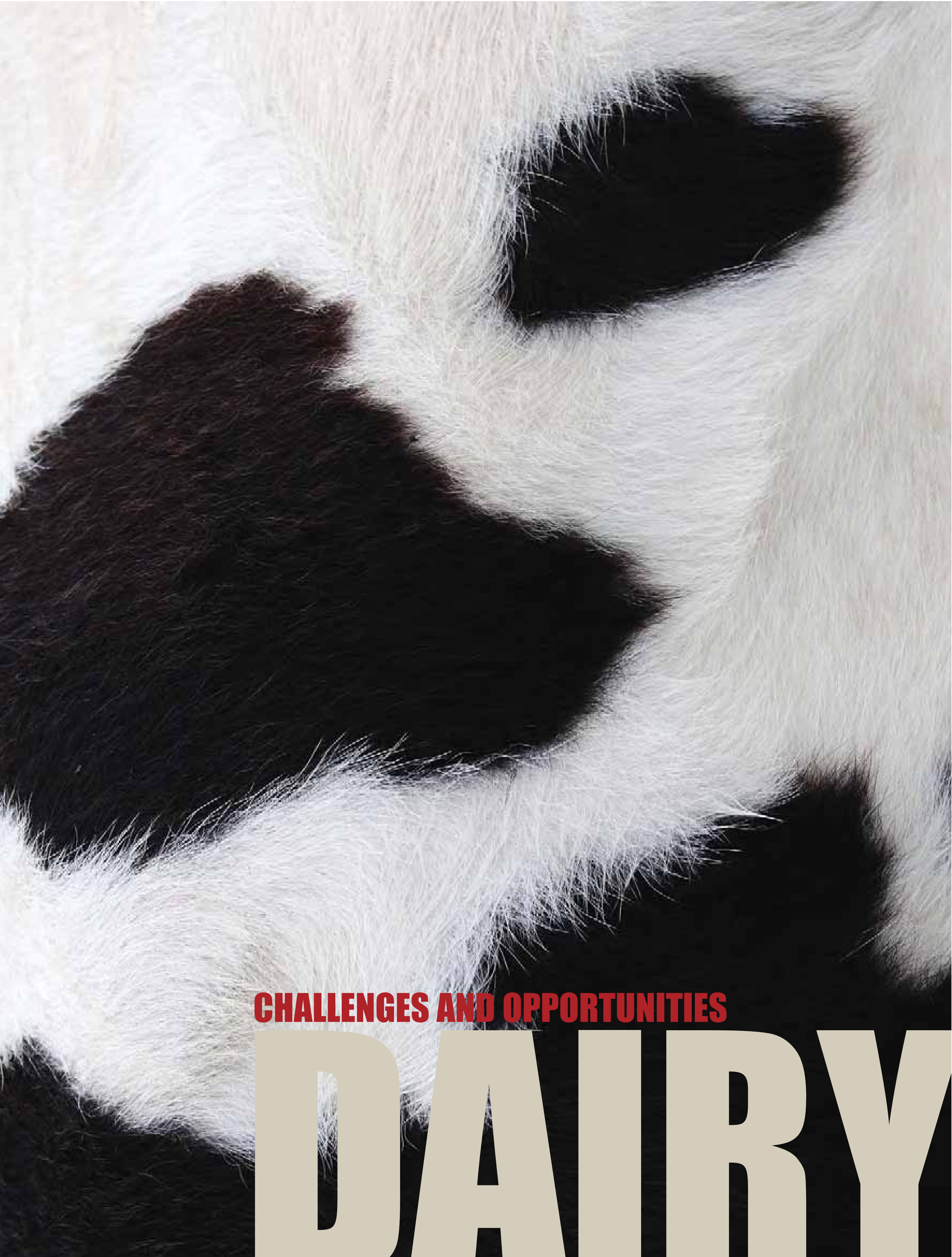
Teagasc will host a series of Science Week events at its research centres nationwide.

The Walsh Fellowships Seminar has been scheduled for November 11 in the Royal Dublin Society.
catriona.boyle@teagasc.ie www.teagasc.ie www.scienceweek.ie

November 12 — *Hudson Bay Hotel, Athlone*

Equine Conference

www.teagasc.ie



CHALLENGES AND OPPORTUNITIES

DAIRY

Providing technologies for profitable expansion

Change is inevitable in the global dairy market as a result of the forthcoming end of the EU's quota regime. Guest editors PAT DILLON and CATHAL O'DONOGHUE put this special dairy supplement in context

The dairy sector is at a crossroads. Like the rest of the economy, it faces significant difficulties in 2009 adjusting to recession and falling world prices. At the same time, due to changes in the Common Agriculture Policy (CAP), the dairy sector will soon face an opportunity, for the first time in a generation, to expand. This special issue details how Teagasc, the national authority for research and development in agriculture and food, is deploying significant resources to facilitate the sector, both in meeting current challenges and taking advantage of future opportunities.

The dairy industry is one of the most important sectors of Irish agriculture, accounting for 30% of output; making a major contribution to the Irish economy; employing 20,000 dairy farmers, 9,000 in the processing industry and an additional 4,500 in ancillary services; and, helping to sustain rural communities. It is a major contributor to exports, as the tenth largest exporter of dairy products in the world, and has remained quite resilient in the face of the economic downturn, maintaining its share of total exports. With the highest margins, dairying has a relatively greater opportunity for expansion and thus can help Ireland to realise future export-led growth.

The significance of the present time is that a policy that has restricted expansion in the past, the dairy quota regime, will not be extended by the EU Commission beyond March 31, 2015. In the interim period, expansion will be facilitated by the recent 'CAP Health Check' allowing for a 1% increase in milk quota each year for the next five years in addition to the once-off 2% increase agreed in 2008/'09. Adjustments to butterfat content may also potentially increase Irish milk quota by a further 2%. While there are will be fewer institutional obstacles to expansion, there are many market challenges. However, because of its pasture-based system, Ireland has a natural cost advantage in dairy production over rivals. Despite the current economic difficulties, the outlook in the medium term is positive due to significant world demand for dairy products based on increasing world population and economic growth in developing countries. Exploiting these natural advantages, Ireland can strengthen its world market position.

Whether the focus of the sector is to maintain profitability within an increasingly volatile or competitive world, or to undertake more ambitious objectives in increasing market share in the post-quota environment, the sector will have to succeed on the multiple fronts of increasing productivity, reducing costs, increasing scale and finding higher value-added opportunities, while at the same time meeting stringent expectations of the public in terms of environmental standards. Teagasc has prioritised within its recent strategic planning document, 'Teagasc Foresight 2030', to provide a leadership role in supporting these ambitions. Consistent with this strategic goal, Teagasc has developed research, extension and education programmes to assist the sector in this goal, underpinned by cutting-edge research.

Research is being undertaken to produce a higher performance from grazed grass, greater use of high EBI genetics, and improved animal breeding and health to promote increased productivity and improved milk quality. Labour efficient low fixed-cost systems are being developed to reduce costs. To aid an increase in scale and in conjunction with key industry stakeholders, a 'Greenfield Dairy Project' is being developed which will provide a blueprint for expansion in existing and new family-run dairy units capable of sustaining high profit. In addition, strategies are being developed to address land acquisition obstacles to allow farmers to increase scale through alternative partnership-based strategies. Research is also being undertaken to identify higher value-added dairy products, such as functional foods, that will command a higher milk price.

Underpinning the science-based approach, are economic analyses to identify the most efficient production models, developing milk pricing systems that will be more effective in transmitting market signals through the supply chain and to provide market intelligence in terms of competitive position and in terms of the impact of policy and market changes. Significant investments are also being undertaken in the environmental area to address issues such as water quality and the greenhouse gas reduction challenge.

Lastly, it is not sufficient merely to develop technologies and strategies; the success of the strategy will depend upon implementation. Research is taking place in developing optimal technology transfer mechanisms. An example is the 'BETTER' farm initiative, which will identify key operational capabilities in the application of best technology, farm infrastructure and layout, operations management protocol, and financial management plans.

This special issue of *TResearch* is Teagasc's first step in fulfilling the objectives set out in the 'Foresight 2030' report in providing a leadership role in the context of an expansion in milk production. The information outlined will ensure that Irish dairy farmers in the future will have the technologies, information and support needed to expand their dairy business profitably, while protecting natural resources at the same time.

Pat Dillon, Head of Centre, Teagasc, Moorepark Dairy Production Research Centre, Fermoy, Co. Cork and **Cathal O'Donoghue**, Head of Centre, Teagasc Rural Economy Research Centre, Athenry, Co Galway.
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Is dairy farm biosecurity good enough to deal with herd expansion?

The results of the first national survey of Irish dairy farmers' biosecurity practices and how these findings should underpin future herd expansion are outlined by RÍONA SAYERS and JOHN MEE, Teagasc, Moorepark Dairy Production Research Centre.

What is biosecurity?

Biosecurity is the measures taken by farmers, their veterinary practitioners and agricultural advisors to prevent the introduction and spread of infectious diseases. At national level the public are familiar with the term from the 2001 Irish foot-and-mouth disease outbreak. Pig and poultry producers are also highly sensitised to biosecurity. However, on dairy and beef farms, where most infectious diseases are far less obvious than foot-and-mouth disease, the focus on biosecurity may be lower. The last study of biosecurity on Irish dairy farms was conducted over a decade ago, so until now we had no data on current practices. In that decade we have seen the emergence of 'new' infectious diseases in Irish dairy herds, including neosporosis and mycoplasmosis, and the apparent increased incidence of other infections such as bovine viral diarrhoea virus (BVDv) and bovine herpes virus-1 (infectious bovine rhinotracheitis; IBR). We have also had increased availability of vaccines to assist in the prevention of infectious diseases of cattle.

Biosecurity is a critical component of successful herd expansion, with strategies such as testing and quarantining of newly purchased stock significant contributors to minimisation of the risk of disease introduction. Without current information on biosecurity as it relates to Irish dairy farms, it would not be possible to adequately assess the risks to Irish dairy herds from future changes in disease epidemiology and farm management practices, such as herd expansion. In addition, the baseline data generated from this survey can be used to monitor the uptake of biosecurity strategies among Irish dairy farmers in future studies.

National biosecurity survey

Teagasc client dairy farmers were surveyed about their awareness of biosecurity and their opinions on the impact of implementing a biosecurity plan on their farm. A total of 11,390 clients were listed on the database representing approximately 60% of the total dairy farmer population in Ireland. Proportional random sampling based on two-tier stratification (geographical location and milk quota size) was used to enrol farmers. A total of 704 questionnaires with 19 questions were posted from July to September 2008, and each farmer was telephoned within one week to record responses. Responses were collected from 450 farmers in 24 counties (a response rate of 64%). Biosecurity was defined on each questionnaire as "the protection of a herd from the introduction and spread of infectious diseases", in order to ensure a uniform understanding of the term in responses. Data were collated by SurveyMonkey, a web-based software company.

Biosecurity is important but under-applied

The majority (72%) of farmers considered biosecurity important. However, 53% stated that a lack of information prevented them from implementing biosecurity practices. Farmers did not proactively seek information on disease prevention measures, with 93% and 78% stating that they 'rarely' or 'never' requested biosecurity information from their Teagasc advisor or veterinary practitioner, respectively. The importance of a closed herd in the prevention of infectious disease introduction is under-promoted, with over half of dairy farmers operating

Table 1: Do you test bought-in cattle for any diseases besides TB and brucellosis?

Survey response	%	Why not? (n = 242)	%
Yes	7.5	It is of no benefit	21.1
No	89.4	I don't know what diseases to test for	20.3
Sometimes	3.1	I was never advised to	44.6
		It is too expensive	14.0

Table 2: Which of the following do you do to avoid buying animals with disease?

Survey responses (multiple responses possible)	Response count	%
Total respondents that purchased cattle	262	
I talk to the seller	179	68.3
I look at the cattle	147	56.1
I request test results for the cattle	97	37.0
I talk to the seller's vet	3	1.2
I request a veterinary health certificate for the cattle	7	2.7
None of the above	29	11.1

open herds (**Figure 1**). As movement of a single infectious animal onto a farm can potentially result in a costly disease outbreak, efforts must be made to change the cattle movement profile of dairy herds. This critical risk factor for disease introduction will assume much greater importance in the future with increased cattle movement between herds as dairy farmers expand their herds through cattle purchases. At the current replacement rate farmers will have to resort to purchasing cattle of unknown disease status with the attendant biosecurity risks.

Diagnostic testing is under-utilised

The survey also highlighted that the importance of diagnostic testing in disease prevention is not well recognised, with 90% of dairy farmers indicating that they did not test purchased animals for any diseases other than tuberculosis and brucellosis. A lack of knowledge and advice would appear to be the main underlying reasons for the under-utilisation of diagnostic testing (**Table 1**).

Similarly, of those farmers surveyed that purchased cattle (n=262), only 2.7% requested veterinary health certificates for purchased cattle (**Table 2**). This

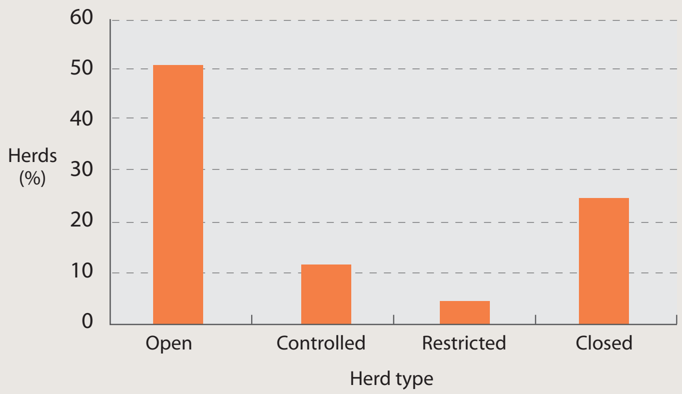

FIGURE 1: Cattle movement profile of 448 Irish dairy herds.
Open: *Free movement of cattle onto the farm;*
Controlled: *Written health history required for purchased cattle;*
Restricted: *Only re-entry of existing cattle allowed; and,*
Closed: *No movement of cattle onto the farm.*

presents challenges both for vendor farmers, who usually don't have a herd health programme in place that would reassure purchasers, and for veterinary practitioners reluctant to certify the health status of the herd or cattle to be purchased without such a programme. The need for herd health programmes as part of biosecurity management will assume greater significance as the level of cattle trading increases in the coming years. As with diagnostic testing, **Table 3** indicates that lack of information would appear to be the primary reason preventing farmers from implementing biosecurity measures, with 53% stating that they do not have enough information. This knowledge gap can be filled by veterinary practitioners and, in future, Teagasc advisors; but, farmers need to be proactive in seeking out this information. Proper quarantine is also extremely under-utilised, with only 20% of farmers stating that they always implement proper quarantine procedures.

High vaccine uptake

The uptake of vaccines was much greater than the uptake of other biosecurity practices or diagnostic testing, with leptospirosis, clostridia and BVD vaccines being most commonly used (**Table 4**). Vaccines were used in 87% of herds.

Vaccines play an important role in the control of many infectious diseases. However, their use without the supporting knowledge provided by diagnostic testing, and the implementation of a biosecurity plan, could potentially undermine their effectiveness in a disease control programme. They should be viewed as a component of a control programme but not as the sole means of disease prevention within a herd (**Figure 2**). Over-reliance on vaccination without the back-up of proper management, biosecurity and diagnostics should be avoided, with vaccine breakdown a potential consequence.

Herd health for the future

With 93% and 78% of surveyed farmers stating that they 'rarely' or 'never' requested biosecurity information from their Teagasc advisor or veterinary practitioner, respectively, it is clear that it is necessary to orientate farmers and their supporting network toward preventive rather than curative animal health strategies. However, the survey did indicate that dairy farmers are willing to adopt an integrated herd health programme, with 60% of respondents indicating that they would voluntarily join a cattle health scheme combining biosecurity, vaccination and diagnostic testing. More importantly, they responded that they would pay a premium price for cattle from such a scheme. Similarly, 86% of farmers

Table 3: What might prevent you from implementing biosecurity on your farm?

Survey response	%
I don't have enough information on what to do	53.4
It would cost too much money	19.3
I don't have the time	15.6
I don't feel it would reduce disease on my farm	11.7

Table 4: Vaccine use among 440 Irish dairy farmers.

Vaccine	%
BVD	41
Calf diarrhoea	15
Clostridia	44
IBR	7
Leptospirosis	61
Pneumonia	8
Ringworm	2
Salmonellosis	27

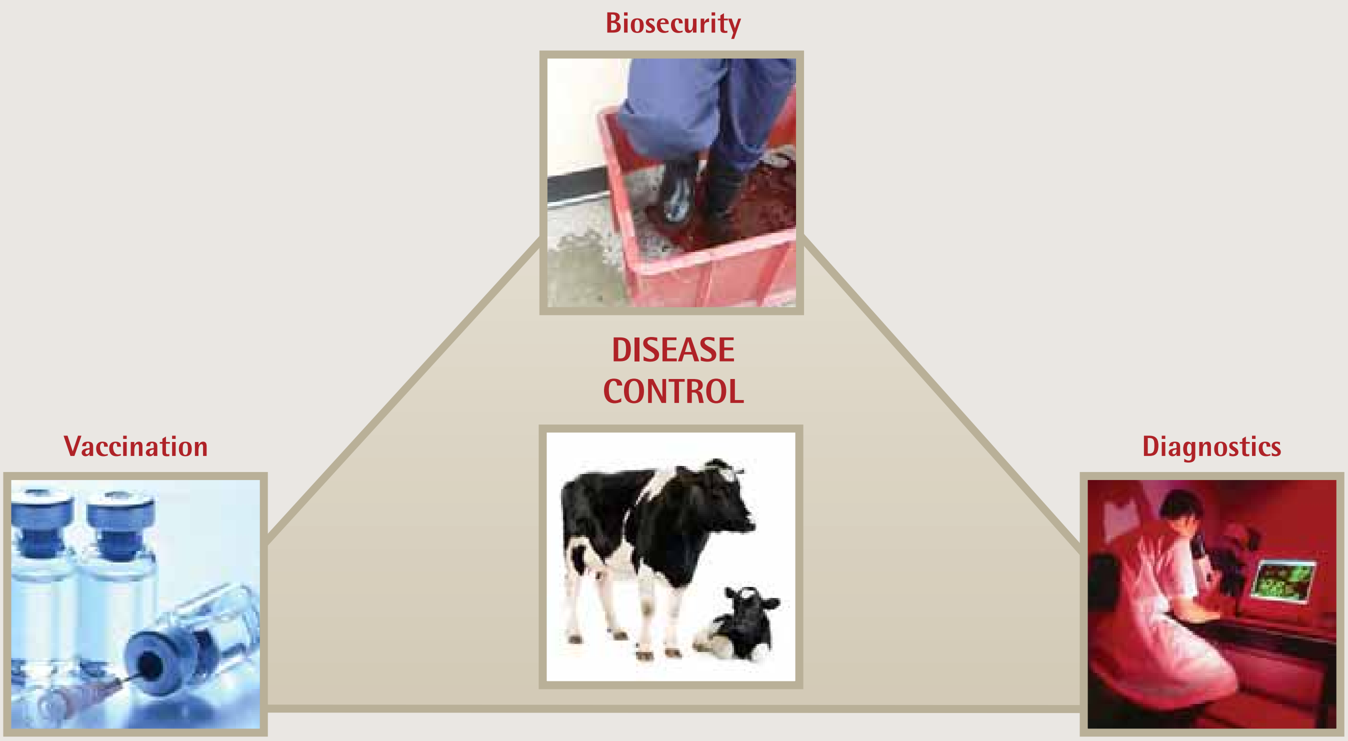

FIGURE 2: Components of an on-farm health planning and disease control programme.

indicated that they would implement biosecurity guidelines, if supplied. However, 35% of farmers stated that they might be prevented from implementing such measures through lack of time or the costs involved (**Table 3**).

Conclusions

The results of this national survey highlight the necessity to present biosecurity to dairy farmers as a practical and economically feasible package, which will prepare them for the risks associated with expanding their dairy herds in the future. In this regard, the establishment of Animal Health Ireland, chaired by Mr Mike Magan, will assist greatly in the co-ordination of biosecurity advice and in the further education of farmers and their advisors to raise the level of knowledge and competence on dairy herd health matters.

This research was supported by the Irish Dairy Levy Research Fund.

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Expansion potential, costs and returns

Teagasc researchers have been examining the costs of expansion and the associated potential returns for dairy farmers.

The recently agreed CAP reform (the Health Check) will see an increase in Ireland's milk quota allocation of 1% per year between 2009 and 2014 and a reduction of the milk quota correction from 18 litres to nine litres in every 1,000 litres for every 0.1% increase in milk fat concentration above the reference levels. EU Member States have already agreed that the milk quota regime will not continue beyond 2015 and this latest reform represents a continuation of the EU policy to reduce the levels of market support within the EU and to allow the countries that are efficient at producing milk to expand production. For the vast majority of Irish milk producers, this reform constitutes the first significant opportunity to expand milk production since 1984. While current milk prices might not give rise to much enthusiasm for expansion, and in fact are causing severe cash flow issues at farm level, it is important for farmers to look beyond the current market gloom and plan for a viable future in milk production. The relaxation of milk quota policies will force Irish farmers to assess their own position in relation to future milk production. Irish dairy farmers will have to decide, in the short term, do they plan to expand their dairy business, remain static or exit milk production altogether. Milk price volatility, as experienced in 2008/2009, will also force Irish farmers to reassess their costs of production in order to ensure that they can withstand extreme low milk price scenarios. This article assesses the potential and financial feasibility of expansion on Irish dairy farms.

Potential for expansion

The level of specialisation in milk production in Ireland tends to be low by international standards because the Irish dairy industry was at a lower level of dairy specialisation when milk quotas were introduced in 1984, compounded by historical milk quota policy. This low level of specialisation in dairy production means that there is significant capacity to increase cow numbers on existing holdings. National Farm Survey data show that on average just 56% of livestock on dairy farms are dairy cows and when replacement heifers are included, this rate increases to 67% of all animals.

While the National Farm Survey data reveals the extent to which farmers could increase cow numbers on existing holdings, it has not solicited the views of farmers in relation to future production plans. In 2007 and 2008 Moorepark Production Research Centre conducted a number of surveys of dairy farmers across nine different milk processors to ascertain their opportunities, challenges, attitudes and intentions to future milk production. A total of 2,300 randomly selected dairy farmers were surveyed out of a potential pool of 13,000. The surveys started with Glanbia in January and February 2007 and finished with the four West Cork Co-ops in the summer of 2008. The processors surveyed were Glanbia, Lakeland Dairies, Connacht Gold, Donegal, Kerry, Drinagh, Lisavaird, Barryroe and Bandon. The surveys were carried out across 2007 and 2008 when milk price ranged from 24c/l to 38c/l and therefore it is anticipated that future intentions would change somewhat with milk price. The objective of the surveys was to identify the potential for expansion and future intentions of dairy farmers. **Table 1** shows some key results from the surveys. The average milking platform size is currently 38.2ha with an average herd size of 58 dairy cows. The average stocking rate around the milking platform is 1.74 cows/ha. There was significant variation around land area (24.3-44.2ha), cow numbers (42-65 cows) and stocking rate (1.58-1.82 cows/ha). The results show that there is substantial potential for expansion on current milking platforms. Experimental and commercial farm data show that in a no quota scenario, systems of milk production will be optimised at close to 3 cows/ha where grass growth and utilisation are maximised and minimal purchased feed is used.

Profitable expansion

The economics of milk production at farm level will dictate the extent to which national milk supply will increase when milk quotas are removed. The current production costs and the cost of expansion will be the main determinants of expansion with the milk price determining the speed of expansion in a profitable expansion plan. Current production costs are an important element in examining the feasibility of expansion within the context of a fluctuating milk price. Costs of production in Ireland in 2008 varied from 16.4c/l on the best 10% of farms to 28c/l on the highest cost 10% of farms. The remaining margin must be sufficient to give a return for all owned resources employed in the business including land and labour. Clearly the ability to supply and increase milk production following milk quota removal depends on current cost efficiency, the ability to improve efficiency and the cost of expansion. Before engaging in any expansion plan farmers will need to evaluate their current cost structure.

TABLE 1. Key summary results from surveys from nine different milk processors.

	Average	Range
Milking platform (ha)	38.2	24.3-44.2
No. cows	58	42-65
Stocking rate (cows/ha)	1.74	1.58-1.82
No. replacement animals	14	10-15
More than adequate housing (% farms)	21.3	14.5-30.1
Potential to convert existing housing (% farms)	41.5	33-47
Future intention – Planning to expand (% farmers)	49.5	35.9-69
Future intention – Planning to remain static (% farmers)	40.3	26.2-52.7
Future intention – Planning to exit (% farmers)	10.2	3-14

Expansion on existing dairy farms

There are a number of different stages to expansion on dairy farms. However, the principle of expansion is similar across all stages. Firstly, the main focus must be on producing the additional milk from increased grass utilisation. Secondly, the level of specialisation of the production of milk must increase. Expansion through the increased purchase of high cost feed will result in a substantial reduction in overall profitability at low milk prices as currently observed. All of the expansion phases on dairy farms will have to centre on low cost capital investment to ensure liquidity in a fluctuating milk price. There will be an increased level of borrowings on an expanding dairy farm. An analysis was conducted to determine the effect of expansion on the financial position of the farm. In the analysis the expansion was divided into three stages with borrowing requirements of €93,714, €32,331 and €121,059 at each stage. Borrowing was required to fund expenditure on increased dairy stock, cow housing and increased milking facilities including a larger milk tank. It was assumed that the cost of a replacement heifer was €1,550, and the capital cost of housing conversion and/or low cost accommodation was €600 per additional cow. It was assumed that a new bulk milk tank would be required during the expansion and that there was a requirement for an extra milking unit for every seven additional dairy cows. The analysis was carried out with a milk price of 30 and 24c/l. The average dairy farmer in terms of cow numbers, stocking rate, grazing platform and capital infrastructure from the survey of the nine dairy processors was the starting point.

The expansion was divided into 3 stages for the purpose of this analysis.

Stage 1 - Expansion is based on the use of more dairy AI and, subsequently, rearing more heifers. Dairy livestock replace alternative livestock enterprises and overall stocking on the milking platform increases to 2.5-2.8 cows/ha.

Stage 2 - Expansion is based on moving the replacement animals to an outside platform, or contract rearing enterprise, and increasing stocking rate to 2.8-3.0 dairy cows/ha on the milking platform.

Stage 3 - Expansion is based on increasing the stocking rate further to 3.5-3.8 cows/ha on the milking platform with the result that only a small amount of the grass silage requirement is being met from the milking platform. The majority of the winter feed requirement will originate from an external land source where the cows will be moved to for a part of the year. This level of expansion can only be justified if the over wintering feed source is provided from a low cost source such as the *in situ* grazing of forage crops. The overall farm stocking rate will comply with the Nitrates Directive.

Table 2 shows the effect of the three different stages of expansion on labour costs, interest and capital repayments, total costs, farm net profit and net profit per hectare. The analysis shows that there is significant potential to increase output on the average farm modelled. The results show that net profit/ha were increased by €790, €1,509 and €1,802 for expansion stages 1, 2 and 3, respectively, compared to the standard system at a milk price of 30c/l. The corresponding figures at 24c/l were an increase of €442/ha, €872/ha and €906/ha. The effect of milk price on the overall sustainability of the systems highlights the requirement to minimise the capital costs of investment on the farm. Cow numbers increased from 58 to 144 cows through the different stages of expansion. This will have significant effects on the overall net worth of the business, which should be a key objective of any business or dairy.

Conclusions

For many dairy farmers the forthcoming reforms to the EU milk quota regime will represent the first real opportunity to expand milk production. Analysis has shown that significant capacity and potential exists at the farm level to expand production even on existing land holdings. However, current milk price volatility is such that the cash requirements and future liquidity of the business must be key components in the expansion plan. Better utilisation of grass and investment in low cost housing are the foundations of viable expansion. There is an urgent requirement for all dairy farmers to develop business plans that will include both long-term and short-term objectives and requirements. All dairy farms should develop a mission statement that will drive the overall objective of their dairy farm business. The technology is available to create the opportunities that will underpin any expansion at farm level. Insulation from a large proportion of the volatility can be achieved by focusing the dairy farm business around low cost grass-based technologies.

TABLE 2. Increase in potential profitability as dairy farms expand

		Expansion		
	Base	**Stage 1 all dairying**	**Stage 2 replacements reared off-farm**	**Stage 3 external feed**
Stocking rate cows/ha	1.66	2.7	2.9	3.7
Concentrate (kg DM/cow)	640	480	390	496
Grass utilisation (kg DM/ha)	7,500	11,056	13,046	14,151
Milk output (kg milk solids)	19,864	33,387	47,177	58,140
Milk output (kg milk solids/ha)	520	874	1,235	1,522
Cow numbers	58	93	112	144
Labour costs (€)	16,458	26,395	31,821	40,874
Interest costs (€)	8,040	15,004	19,863	25,989
Capital costs (€)	4,168	7,805	10,524	13,769
Total costs (€)	84,544	121,624	168,544	214,840
		Milk price 30c/l		
Milk receipts (€)	87,180	147,727	210,382	259,383
Farm net profit (€)	13,799	44,195	71,885	83,142
Net profit €/ha	358	1,148	1,867	2,160
		Milk price 24c/l		
Milk receipts (€)	69,670	118,055	168,543	207,799
Farm net profit (€)	-3,818	13,343	29,897	31,242
Net profit (€/ha)	-95	347	777	811

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Dairy farming in Ireland

ANNE KINSELLA and colleagues examined the financial and technical performance of Irish dairy farms and made some comparisons with other EU Member States.

Irish agricultural output is still overwhelmingly based on grass and ruminant livestock, with crops accounting for less than 30% of agricultural output value versus an EU share of 57%. Unlike many other EU countries, Irish agriculture is not very specialised, with most farms still operating more than one enterprise on their farm. In 2007, ruminant meat and dairy production in Ireland accounted for 59% of output while the comparable share in the EU27 was 25% (source: Eurostat). The number of specialist dairy farms in Ireland has declined from over 40,000 farms in 1991 to approximately 20,000 active dairy producers in 2007, as highlighted in the Farm Structures Survey (FSS) 2007, published by the Central Statistics Office (CSO) (**Figure 1**). There are a total of 1.06 million dairy cows in Ireland, representing 16% of all cattle in the country. The number of dairy cows has been falling quite steadily since 1991, because milk yields are rising and fewer cows are required to meet the milk quota. For 2007, there were more dairy cow herds in the herd size category 50-99 head than in any other herd size category, while in 1991 most herds were in the 10-19 head size group. In the EU, Germany has the highest number of dairy cows, totaling over four million, with France having over 3.5 million. The FSS looks at (among other items) time demands on holders. In relation to this, the specialist dairy farms show the greatest demands on time, with 86% of dairy holders in 2007 working a full Annual Work Unit (AWU), while for all holders the percentage was 53%.

Some EU comparisons

It is interesting to compare the Irish dairy sector with other EU Member States (MS). This comparison reveals that the dairy sector in Ireland is relatively unique in many respects. Primarily because of climatic issues, Ireland has a comparative advantage in the production of low cost seasonal milk. Unlike other countries with longer winters and/or lower rainfall, a low cost system is economically viable in Ireland. In addition, Ireland has a relatively low population, and thus exports the bulk of its milk. Although fresh dairy products are quite lucrative in terms of value added, it is difficult to export fresh dairy products due to our distance to market, the limited shelf life and the high transportation costs to value ratio of fresh dairy products. As a result, the majority of Irish dairy exports are of the form of bulk commodity products, which can be more easily stored and shipped at relatively low cost. Also, a considerable volume of the dairy products produced in Ireland enters the food sector as ingredients for other products (e.g., pizza cheese) rather than being purchased directly by consumers at a retail level. A consequence of the low cost, grass-based system with low level of (expensive) concentrate supplementation is that milk yields in Ireland are relatively low in the EU15 (**Figure 2**). At less than 5,000kg/cow/year, yields in Ireland are much less than in the UK (6,800kg), France (6,300kg) or the Netherlands. This is due to a combination of factors including breed, feeding regime and lactation length. The research programme at Moorepark is developing technologies to improve these issues, while maintainig a low cost base.

A further consequence of the low cost, seasonal approach to milk production is that the scale of processing capacity must cater for the levels of milk production in the peak milk delivery months, but is relatively under-utilised in the lower output months during the winter. This means that the total throughput of milk in Irish processing plants is low relative to the plant size. Improvements are required in the organisation of the milk processing industry to improve the efficient use of the capital employed.

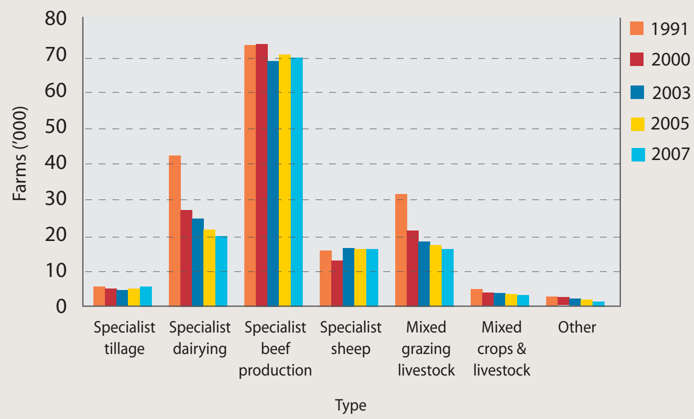

FIGURE 1: Farm types, 1991-2007. Source: CSO Farm Structures Survey 2007.

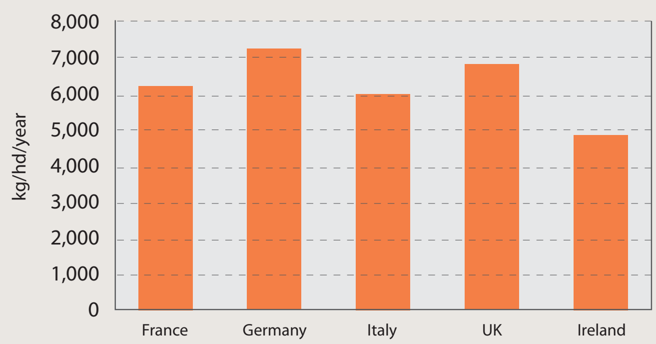

FIGURE 2: Milk yields per cow in various EU MS – 2007. Source: FAPRI EU GOLD Model.

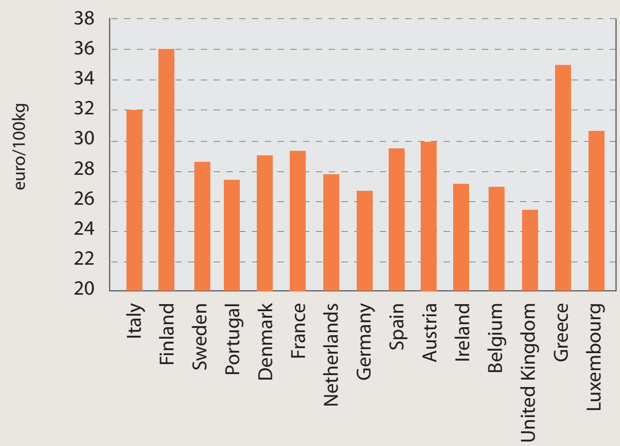

FIGURE 3: EU 15 milk prices (2006). Source: DG Agri. Note: 2006 used as it is more representative than 2007 or 2008, as milk prices in 2007 and 2008 were abnormally high in comparison with other EU countries.

Ultimately, therefore, because of the focus on low cost bulk products produced by the processing industry, the price paid to farmers for milk in Ireland tends to be much lower than that in neighbouring MS (**Figure 3**).

Financial and technical performance of dairy farms – National Farm Survey

Irish agriculture is very much an export-oriented sector, showing large diversity in profitability across different farm enterprises, with gross margins per hectare on dairying production systems returning higher gross margins per hectare than tillage, beef or sheep production systems. The dairy sector represents the more commercial sector of Irish agriculture and appears set to increasingly dominate Irish agriculture. Based on 2007 National Farm Survey (NFS) results, the dairy sector accounts for approximately 50% of total agricultural output and 50% of income arising for the agricultural sector. The NFS carries out an annual survey on a random sample of farms, selected by the CSO. The results are weighted to represent the main farming systems and the overall farm population. Farms are classified into the dairy system when dairying is the dominant enterprise on the farm. The 2007 NFS results represent the financial and technical performance on approximately 25,700 dairy farms in the two main dairying systems, viz., mainly dairying, and dairying and other. Scope exists for increased specialisation in production, with 15% of farms in the NFS classified as specialist dairy farms and 8% classified as dairy/other.

NFS data show that dairying has been consistently the most profitable system of farming over the last three decades. Family Farm Income (FFI) is the principal measure of the income, which arises from each year's farming activity, representing the financial reward to all members of the family who work on the farm for their labour, management and investment in the farm business. The trend in FFI per farm over the period 2003 to 2007 is shown in **Figure 4** for the main systems of farming.

The data show that on a per farm basis the specialist dairy system yields the highest FFI over the five years, with cattle rearing system earning the lowest incomes. Over the period, FFI was also high for farms in the tillage system. However, FFI per farm data does not take into account differences and changes in farm size between the farm systems. FFI calculated on a per hectare basis for the same systems show an increase in the financial returns in favour of dairy farms, as tillage farms are much larger than dairy farms, resulting in lower returns per hectare. The NFS analysis divides farmers into full-time and part-time; the full-time farms are those that require a minimum of 0.75 standard labour units to operate, calculated on the basis of labour requirements for each farm enterprise. Dairy farms accounted for almost 60% of full-time farms in 2007 and the average income on all full-time farms was €43,940 per farm compared to an average income of €8,000 on part-time farms. Data in **Table 1** show financial and technical data for farms in the specialist dairying system in 2007. Dairy farms have the highest gross output per ha compared to other farm systems. However, subsidies have been making an increasing contribution to dairy farmers' output and incomes. In 2007, subsidies contributed 15% to output and 38% of FFI. The efficiency and competitiveness of agriculture can be examined by calculating the costs of production for the main products. Nationally, in 2007 approximately 63% of gross output was absorbed by direct and overhead costs. On specialist dairy farms total costs absorbed 60% of gross output. However, if subsidies are excluded from output on dairy farms, then costs as a percentage of the market-based value of gross output in 2007 was 71%. In comparison to the other farming systems, dairy farms in 2007 had the highest stocking rates, the youngest farmers, the highest percentage demographically viable and the lowest off-farm employment.

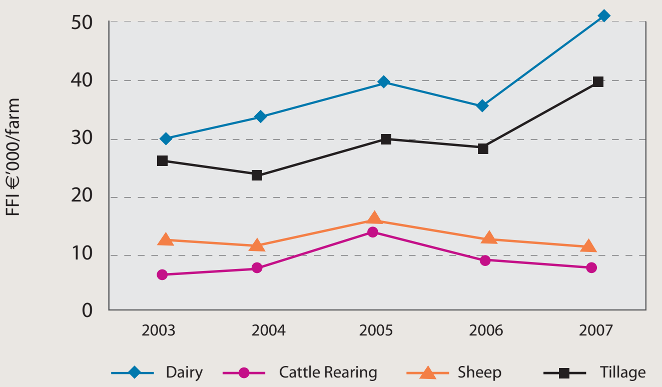

FIGURE 4: Family Farm Income (FFI) per farm by farm system (2003-2007).
Source: National Farm Survey.

TABLE 1: Financial and technical performance on specialist dairy farms – 2007.

	Specialist dairy system €/farm	€/ha
Gross output	128,564	2,857
of which subsidies	19,453	432
Direct costs	41,555	923
Gross margin	87,009	1,934
Overhead costs	35,992	800
Family Farm Income	51,017	1,134
Land farmed (ha)	45	
No. of dairy cows	51	
Total livestock units	82	
Labour units	1.51	
Farmer age	51	
Married (%)	77	
Off-farm job – farmer (%)	14	
– spouse (%)	44	
– farmer/spouse (%)	51	
Demographically viable* (%)	86	

Source: National Farm Survey.
*Percentage of farm households which have at least one member below 45 years of age.

Further reading

http://ec.europa.eu/agriculture/analysis/fadn/reports/sa0207_milk.pdf

The Excel annexes are also available from the website:
http://ec.europa.eu/agriculture/analysis/fadn/index_en.htm

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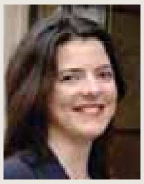

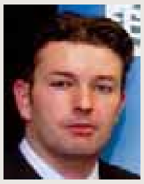

Competing on a world stage

Expansion of the dairy industry would bring issues to bear on both dairy farmers and processors, say TREVOR DONNELLAN and KEVIN HANRAHAN.

The EU CAP Health Check agreement of November 2008 has provided clarity on the future of the EU milk quota. The overall increase in EU Member State milk quotas between now and the elimination date of 2015 will be just 5%. In effect Irish dairy expansion will be held in the starting blocks until 2015. While milk prices at present do not give grounds for enthusiasm for dairy expansion, the longer term outlook for dairy markets is more positive. Therefore, it is worthwhile considering how to prepare for a world without milk quotas.

World and EU dairy markets over the last couple of years have experienced extreme price swings. Record high milk prices have been followed by very low prices. These high and low prices represent extremes and the longer term path of milk prices should be somewhere in between.

While the cost of producing an additional unit of milk (the marginal cost) is below the price received for that milk, then production will continue to expand. Future milk prices and future marginal costs of production will be key determinants of the future level of milk production. Dairy product demand will continue to increase in the EU in the period to 2015 and beyond and the increase in the EU milk quota should allow an expansion in aggregate EU production of 2% to 3%.

Even without a WTO agreement, the EU Commission has signalled an unwillingness to make significant expenditures in the area of dairy export subsidies. This will be a particular problem for the butter market, especially if the EU Commission sticks to its intention to manage EU butter prices at a level close to the intervention price.

Research from the FAPRI-Ireland team at Teagasc's Rural Economy Research Centre indicates that over the next decade, milk prices in Ireland are likely to average within a band of 26 to 28 cent per litre. It is important to understand that a considerable amount of cost inflation will be faced by producers, some of it driven by factors outside of agriculture. The price of inputs such as energy, labour, and other costs is unlikely to fall. So to produce saving in this area farmers will need to focus on reduced input usage per unit of output. To achieve a significant level of expansion in milk production, prices for the main input items, feed and fertiliser will need to be considerably below their 2008 levels. Both of these prices are outside the farmer's control.

To what extent can dairy farmers react to this cost inflation? It is clear that significant cost savings would need to be achieved through improvements in technical efficiency. Less feed and fertiliser will need to be used per unit of output.

Feed usage will come under greatest scrutiny. In Ireland feed use per cow still runs at about 800kg/cow/annum, which is close to three times the Teagasc target. Added to that, milk yields on some low input farms significantly exceed the national average which remains below 5,000 litres per cow/year. Nationally, feed usage per litre of milk produced is on average, in excess of three times the Teagasc target at present. If producers can achieve the Teagasc target for input usage and milk production, then the scope for alleviating the impact of the rising price of cost items through reduced volume of input usage is sizeable for a significant proportion of producers.

Even without productivity improvements on individual farms, structural change will lead to an increase in the national milk yield per cow and a decrease in the feed usage per litre of milk produced on dairy farms. A substantial change in farm management practices will be required to bring the national average level of performance into line with the Teagasc target.

Undoubtedly, there are dairy farms with significant expansion potential, where the marginal cost of milk production for an additional volume of production is relatively low. Production increases achieved through extending the short lactation period may fall into this category. However, it is necessary to caution that many farmers have become quite used to a longer winter break and it cannot be said that farmers will extend the grazing season when milk quotas are removed simply because this is possible. It is an option that they may or may not wish to exercise.

Producers who have had difficulty in accessing milk quota in the past and who have a significant non-dairy enterprise may also have a low marginal cost of milk production in that they can remove beef animals from the farm and increase the size of their dairy herd.

There are also a group of milk producers who have low marginal costs of production (through favourable land quality, climate and good grassland management skills), but who are already specialised in milk production and who will find land to be a constraining factor, particularly in regions where dairying is already the dominant farm enterprise. There may be an absence of exiting producers to allow land to be freed up for those wishing to expand. In this instance farmers may have to explore options such as the rearing of replacements on out farms or contracting the rearing of replacements by other farmers.

Some farms may be capable of expanding production where neighbouring farms are exiting production. But this form of expansion is likely to be more expensive than expansion brought about by lengthening lactations or by removing beef animals from the farm system.

Additionally, there is the potential for conversion of beef farms to dairy farms. The costs of setting up a green-field dairy operation will be significant. The capital requirement (particularly in the new financial climate) would be such that it might only be an option for large scale beef producers or for dairy producers who are able to acquire an existing beef farm.

The challenge for the processing sector

While the importance of achieving reductions in the costs of expanding milk production on farms through innovation cannot be understated, it must also be understood that increasing Irish milk production itself creates many challenges for milk processors, which are important in determining the future level of milk prices.

The 5% increase in Irish milk quota between now and 2015 agreed in the recent CAP reform can be processed with the existing processing facilities in the country. Had a larger quota increase been available, then that might have required new facilities well in advance of 2015 and earlier decisions about the future structure of the processing sector and its product mix. Instead, processors are now likely to wait a few years before they decide on what strategy to employ in processing the post-quota level of milk production.

For many years commentators have noted the need for the Irish dairy sector to diversify away from a dependence on intervention and other supported products (butter, SMP and casein). Currently about two and half times as much milk goes towards the production of butter and skim products as goes to cheese. Changing this dairy product mix will be difficult in a period of expanding milk production. The common view is that the sector should move up the value chain to higher value-added products. The challenges in doing this have been significant in the era of the fixed quota and the success to date has been confined to some modest growth in cheese production and the emergence of the infant formula business. It is important to stress that the challenge of breaking away from our current product mix becomes much greater when milk production expands.

By way of illustration, if milk production expands by 25% by 2020 then a number of outcomes are possible:

Outcome A: To maintain the existing production ratio between butter and cheese would require an additional 30,000 tonnes of cheese production (and an additional 40,000 tonnes of butter);

Outcome B: If all of the additional milk was used to make cheese this would require an increase in cheese production of over 100% (an increase of close to 140,000 tonnes) relative to current levels.
It is unclear whether a cheese market for 140,000 tonnes of additional cheese (produced presumably on a seasonal basis) would emerge easily; or,

Outcome C: As a result it is likely that our product mix will evolve from its present state to somewhere in between Outcome A and Outcome B.

The important point is that the Irish milk price will still largely be determined by the price of butter and SMP/casein and we cannot expect to easily move up the EU milk price league in the post-quota environment, since to do so will require a radical change in dairy product mix.

Significant capacity exists

The relatively limited movement of milk quota between farms over the last 25 years, combined with technological progress, has left Irish dairy farmers with a significant capacity to expand milk production in the post-quota period. The future level of milk prices will be determined by the ability of the Irish dairy industry to find markets for the additional milk produced.

The longer term outlook for dairying is positive. Consumption of dairy products continues to grow internationally. At the same time, production also continues to expand globally. Of key interest to a dairy exporter such as Ireland, is the future expansion potential of other major dairy exporters globally. While over the short-to-medium term it seems certain that our competitors outside the EU will continue to expand their milk production, there may come a time when land availability and climatic conditions might constrain their growth, which would be a positive development for the dairy sector in Ireland.

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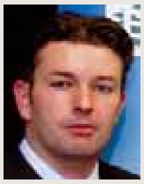

Relative competitiveness of Irish dairy farms

The abolition of milk quotas will create challenges for the competitiveness of Irish dairy farming. FIONA THORNE, Teagasc, Kinsealy, analyses data from the Farm Accounting Data Network to compare relative competitiveness within the EU.

The changes to the EU milk quota regime outlined in the EU CAP Health Check Agreement of November 2008 is expected to have major consequences for the future production level and the location of milk production across the EU. Analysing the impact of such a policy change is challenging. Given that the milk quota constraint has been in place for close to 25 years, little is known about the relative responsiveness of milk production to such a change in policy. The farm level milk price–cost ratio, however, could be considered a leading indicator of the ability of the farm sector to sustain or increase milk production in a post-milk quota situation. In this article, Farm Accountancy Data Network (FADN) data on farm level costs and output are used to assess the relative competitiveness of milk production in the EU at present.

Costs of production as a percentage of output values for specialist dairy farmers were collated for the 2004/2005 period, the most recent years available. **Figure 1** shows the position for the 'average farm' in selected EU member states (MS). These costs of production are decomposed into cash and imputed costs as described in the panel on p.33.

The examination of the cash costs of dairy production in isolation can be useful in that cash costs as a percentage of output value can be used to measure the resilience of the dairy sector to cope with a price–cost squeeze over the short run. For a true competitiveness comparison, however, it is also important to consider the opportunity cost of owned resources. This gives a measure of the total economic costs of production: in the long run both cash and imputed owned resource costs must be covered if the business is to be sustained. Imputed costs can also be used as a leading indicator of the potential for the average dairy farmer in the EU MS to expand profitably, as they reflect the typical costs of land and labour in each country.

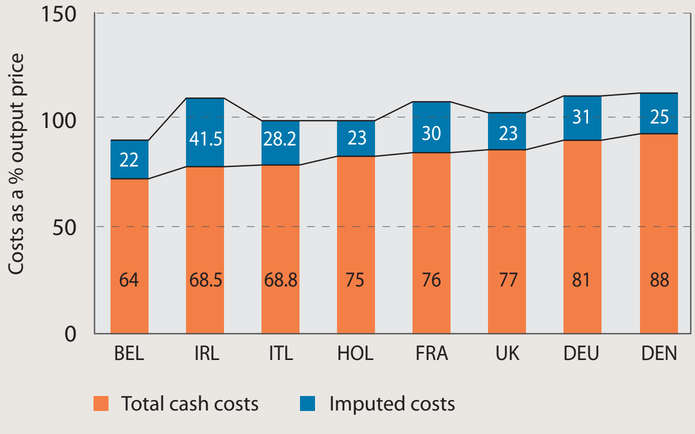

FIGURE 1: Average cash, imputed and total economic costs for all specialist dairy farms in selected EU member states (2004-2005).

Findings

Cash costs as a percentage of output were relatively low in Ireland over the period 2004/2005. This finding is consistent with previous research by Thorne and Fingleton (2006), which was based on the time period 1996 to 2003.

The average Belgian dairy farm had the lowest cash costs as a percentage of output value in the 2004/2005 period. Italy and Ireland had only slightly higher ratios. In terms of cash costs, Denmark was the poorest performing country with cash costs at 88% of output value.

When imputed costs for owned land and labour were included to reflect total economic costs, the results were somewhat different. The relative competitiveness of Irish dairy farms previously displayed when cash costs were considered in isolation dissipated when the imputed charge for owned resources was considered. Total economic costs as a percentage of output were highest in Denmark, where costs were 113% of the dairy enterprise output. Germany and Ireland followed with the second and third highest total economic costs at 112 and 110% of output, respectively. The lowest total economic costs were experienced in Belgium.

Differences in imputed costs across EU MS can be attributed to three main factors: the varying degrees of reliance on owned versus hired resources; the

varying cost of land and labour; and, the relative efficiency of resource use. The main imputed cost that contributed to the relatively high total economic costs experienced in Ireland over the period was that for owned land. This was due to the relatively high imputed rental charge coupled with high levels of land ownership in Irish dairy production. The relatively low stocking rates and milk yields per hectare on Irish dairy farms over the period must also be considered as a contributing factor.

Resource use

Looking specifically at the efficiency of resource use, using FADN data it is possible to derive partial productivity measures of dairy production across the selected EU countries. In particular, milk production per hectare and per labour unit were examined to gauge the level of resource use efficiency among the selected countries. Relatively high milk output per hectare in the Netherlands and Denmark and milk production per labour unit in Denmark, the Netherlands and, to a lesser degree the UK, were evident. These three MS also had among the lowest imputed costs, providing evidence that the more efficient use of land and labour lowers total economic costs. On the other hand, France and Ireland tend to have relatively low output per hectare, while Italy, Ireland and France have low output per labour unit. This lower output per labour unit and per hectare may partly explain the high imputed costs evident in these countries. It could be argued that the various milk quota transfer policies implemented by member states in recent years are responsible for the current structure of farming and, to some degree, may explain the relative international competitiveness of EU MS. In France and Ireland, for example, movement of milk quota between producers has been relatively restricted when compared with quota transfer between producers in Denmark, the UK and the Netherlands, where a freer market for milk quota exists. The poor size structure and low output to resource ratio that now exists in some MS is largely due to the slow pace of structural change as a result of the restrictive quota transfer policies. On the other hand, MS that adopted a more market-based quota transfer mechanism facilitated the restructuring of resources towards more efficient producers, i.e., those that could pay the highest price for quota.

Conclusions

In summary, the competitive position for Ireland was positive when cash costs were considered in isolation from imputed charges for owned resources. However, as the opportunity cost of owned resources are not included in this calculation, this indication of future competitiveness can only be considered to be valid in the short to medium term. In the longer term, adjustment within the sectors will be a reality that will be dependent on relative resource use, and in this situation relative resource costs are needed to understand and analyse the adjustment process. Hence, total economic costs, which include imputed charges for owned resources, are considered a more appropriate indicator of the longer term outlook for the competitiveness of the sector. In doing so, the competitive ranking for the Irish dairy sector slipped relative to the other countries. These findings could be considered as warning signals for the future competitive performance of the average sized Irish dairy farm. Part of the explanation of the deterioration of competitive ranking for the average Irish dairy farm when total economic costs are considered relates to the relatively low scale of primary agricultural activity in Ireland. This result is indicative of the small-scale farming that is predominant in the Irish dairy industry relative to competing industries.

Reference

Thorne, F. and Fingleton, W.A. (2006). 'Examining the Relative Competitiveness of Milk Production: An Irish Case Study (1996-2004)'. *Journal of International Farm Management*, Vol 3, Edition 4 [online publication].

Definition of costs

Cash costs: include all specific costs directly incurred in milk production, for example fertiliser, feedstuffs, seeds, etc., plus external costs such as wages of hired labour, rent and interest paid, plus depreciation charges.

Imputed costs: include family labour, equity capital and owned land. Imputed costs for land and labour were derived by using FADN measures of average land rental and agricultural labour rates in each country.

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Milk production systems post quotas

Recent research results within Irish grass-based systems demonstrate that considerable potential exists to increase pasture productivity through improved management practice in combination with appropriate animals.

The introduction of milk quotas on Irish dairy farms capped production and focused producers on profitability per litre by reducing production costs on their fixed quotas. This policy indirectly motivated producers to increase milk production performance per cow and resulted in gross under-production and utilisation of homegrown feed. Post quotas, and with profitability per hectare as the overarching objective, Irish pasture-based production systems must increase home grown pasture utilisation, reduce supplementary feed usage and develop labour efficient systems that will facilitate increased operational scale. As illustrated in **Table 1**, which outlines the defining characteristics of Irish milk production systems (with and without milk quotas), the production system post quotas will be characterised by increased stocking density to harvest additional pasture, improved nutrient use efficiency through increased use of slurry, increased herd size and an increase in the proportion of grazed grass in the diet. The mean calving date of the herd will vary with location but will be the earliest date possible from an exclusively pasture-based diet with minimal concentrate supplementation requirements.

TABLE 1: A comparison of milk production systems with and without milk quotas.

Production characteristics	Quota	Post quotas
Profitability objective	cent/litre of quota	€/hectare of grazing land
Pasture production (t DM/year)	12-13	16-18
N application (kg N/ha/year)	300	250
Stocking rate (cows/ha)	2.47	2.94[1]
Mean calving date[2]	February 20	February 15
Labour efficiency (cows per LU)[3]	50	100-150
Diet (kg DM/cow/year)		
Grass	4,050	4,400
Silage	1,150	900
Concentrate	350	200

[1]*Subject to Nitrates Directive derogation approval.*
[2]*Calving date listed is for free draining soils in the south and will be up to three weeks later on colder or wetter farms.*
[3]LU = Labour Unit

Grazing practices post milk quotas

At a practical level, Irish dairy farms must now deliver sufficient grazing feed from their own land resources to allow herd size to increase without increasing exposure to high cost external feed sources. Basic practices such as weekly pasture measurement and feed budgeting, soil fertility analysis, on/off grazing and reseeding underproductive swards will contribute to enhanced animal performance from grazed pasture. A future farm system study at Curtins Farm, Moorepark, incorporating these practices with more intensive stocking rates has been ongoing for three years. While still at an early developmental phase in terms of these new systems' characteristics, the implementation of grazing and pasture management practices from Lincoln University, New Zealand, has resulted in a 25% (12.5-16 tons) increase in total pasture production per annum from 2006 to 2008 at the research farm. The approach taken within this study has been to focus on grazing practices that create the ideal environment for growth and for annual paddock yield measurements that are used to select paddocks for re-seeding. This is achieved by maintaining an optimal grazing residual (to ensure maximum green leaf production) and pre-grazing herbage mass (to maintain a leafy sward to the base to trap sunlight from the day of grazing). Optimal growth is achieved by grazing to 3.5cm (**Figure 1**), thereby removing all leaf at each grazing event during the season. The lower residual prevents stem elongation, protects the growing point below grazing height and

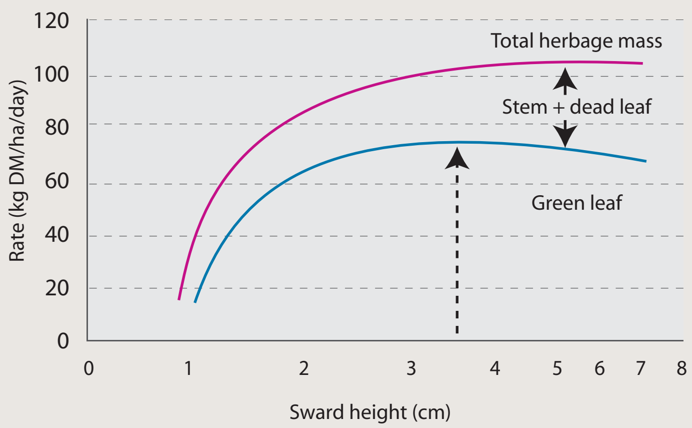

FIGURE 1: Relationship between herbage mass and leaf growth, leaf senescence, and net herbage production in continuously grazed swards (adapted from Bircham and Hodgson, 1983).

avoids shading of the primary growing units, newly formed tillers at the base of the sward. At a practical level, grazing to 3.5cm removes the requirement for topping (which reduces total annual pasture production by 3-5% per annum).

High animal performance from grazed grass is dependent on high grass dry matter (DM) intakes, which can be difficult to achieve with low grazing residual targets. To maintain high daily DM intakes, pre-grazing herbage mass must be maintained at 8-9cm (equivalent to 1,200-1,400kg DM/ha). Current pasture evaluation criteria are based on silage cutting systems, with little emphasis on grazing characteristics. The realisation of pasture varieties that facilitate high animal performance is hugely important to Irish production systems. On that basis, variety evaluation criteria for this system must be developed under grazing to realise varieties that will produce high seasonal DM yields, higher mid-season sward quality and ensure high intake capacity. The necessity to increase pasture production from a grass-breeding perspective has never been more important; however, this production must come in the early and late growing season while also exhibiting higher over-winter growth.

TABLE 2: The impact of genotype on the milk production and reproductive performance of Holstein-Friesian dairy cows within likely futuristic pasture-based production systems.

Genotype	NALow[1]	NAHigh[2]	NZHigh[3]
EBI (€)	46	90	84
Milk sub-index (€)	36	41	41
Fertility sub-index (€)	12	41	50
Milk solids (kg/ha)	1,121	1,138	1,175
Average lactation weight (kg)	562	566	540
Average lactation BCS	2.73	2.77	2.89
Pregnancy rate in 42 days (%)	51	63	69
Empty rate after 13 weeks (%)	23	19	15

[1]North American Low EBI, [2]North American High EBI, [3]New Zealand High EBI.

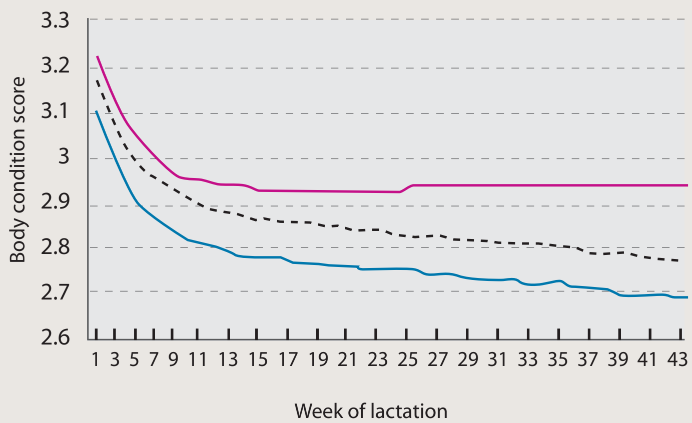

FIGURE 2: The effect of genetic selection on lactation curve for body condition score for the HighNA (– – –), LowNA (——) and HighNZ (——) genotypes.

The realisation of appropriate animals post milk quotas

The system is based on creating the ideal environment within the farm to grow higher quantities of higher energy pasture, which can, in turn, feed additional animals and consequently realise new levels of productivity. Recent results at Teagasc Moorepark have shown that higher Economic Breeding Index (EBI) animals will deliver increased milk solids production within the context of such systems, while exhibiting superior reproductive performance to lower EBI animals. The results also indicate that continued genetic selection for fertility traits will be required to achieve desirable levels of reproductive efficiency.

In combination with the performance parameters outlined in **Table 2**, appropriate animals must exhibit comfort within the production system. As distinct from productivity, BCS and BCS change reflect the overall welfare of the herd within our production systems. On that basis, it is evident from **Figure 2** that a lower production potential animal with a reduced body weight will have lower maintenance requirements at pasture, gain body condition through lactation and, therefore, exhibit greater comfort within the production system.

Ultimately, excellence in grassland management will reach a certain energy production capacity within the farm gate, at which point further increases in productivity can only be realised through increases in feed efficiency. While Irish dairy farms are many years removed from reaching the feed production capacity of their farms, the selection of animals with increased feed conversion efficiency must now begin in earnest to realise such animal characteristics in advance of this necessity. On that basis, recent results from the New Zealand Cattle Database show that within the New Zealand cow population, high genetic potential Jersey/Holstein-Friesian crossbred progeny outperform the two parent breeds in terms of lifetime productivity, survival and feed conversion efficiency.

Conclusions

Recent research results within Irish grass-based systems demonstrate that considerable potential exists to increase pasture productivity (beyond historical levels) through improved management practice in combination with appropriate animals. When this increase in sward productivity is matched with an appropriate stocking rate, the performance and profit potential per hectare of Irish dairy farms can increase significantly in a no milk quota scenario and, on that basis, management systems should now be implemented towards this defining objective.

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Product mix – commodity or higher value-added products?

Researchers at Moorepark Food Research Centre look at future strategies for Irish milk production and dairy product manufacture.

In a series of articles prepared for the *Farm & Food 2000* Millennium issue (Spring/Summer 2000), the authors explored a number of cheese diversification and milk powder manufacturing scenarios. At the time, expanding manufacture of non-Cheddar cheese varieties was seen as an opportunity to reduce over-dependence on the manufacture of commodity milk powders. The thorny issue of ensuring a year-round milk supply for cheesemaking was addressed at the time in a novel cost-effective way by our Dairy Production Research Centre colleagues, who proposed a managed system whereby selected dairy farms would be designated as mainly spring- or autumn-calving milk producers. In the intervening years, dairy farming moved away from entertaining such a proposition and opted instead to maintain the status quo, i.e., spring-calving dairy herds, based on the exploitation of Ireland's natural advantage in grass-based feeding systems. For many years, Ireland's seasonally-based milk production system has impeded the industry from engaging fully in the EU internal market for consumer dairy products owing to the difficulty of supplying on a year-round basis. Moreover, the additional transport cost due to geographical location puts Ireland at a disadvantage as a potential supplier of fresh, short shelf-life dairy products. In addition, the manufacturing scale and market dominance of mainland European dairy companies is a substantial barrier to new entrants supplying semi-hard table cheeses into EU markets. So how does this milk production strategy stack up with market changes in the meantime?

Market forces affecting recent changes in product mix

Significant developments have taken place from an Irish dairy industry perspective in the past decade, including:

1. Steady expansion in the production of Cheddar cheese linked with market demand along with declining milk production in the UK.
2. New demand for dairy products and ingredients arising from market developments in Asia.
3. Increasing recognition of the value of whey constituents.
4. The reduction of intervention prices and increases in the milk quota under the 'Mid-Term Review' and 'Health Check' CAP reform packages. The apparently long-term setting of EU production aid for the manufacture of casein to zero as part of this process has special significance for the Irish milk sector because of its high proportion of EU casein output and capacity.
5. Environmental factors such as drought in Oceania, which affected market supply.

The net effect of these developments is that demand outstripped supply and dairy product prices rose to an all-time high in 2007. Furthermore, expanding Cheddar cheese production provided an alternative outlet for milk fat (other than butter). However, the market outlook is currently dominated by the sudden decline in dairy markets and prices post 2007, the global economic downturn, over-supply in world dairy markets (particularly by countries with low-cost-based milk production systems), and currency fluctuations, e.g., the decline in the Euro/Sterling exchange rate, which affects exports to the UK. Thus, Ireland's current dairy commodity output is significantly exposed to changes in world market prices, while its mainstream cheese, Cheddar, is subject to currency fluctuations because of a dependence on one particular market. This situation could be further exacerbated should future WTO agreements permit imports of dairy products into the EU at greatly reduced tariffs. In addressing appropriate strategies for the dairy industry, one is also mindful of the challenges and opportunities that will arise as a result of increasing EU milk quotas by 1% a year until 2013-14, with a view to their expiry in 2015.

Considerations affecting future product mix

1. Competitive commodity manufacturing capability:
   a. a significant component of Irish milk will continue to be processed in the form of milk powders – a proportion of which will be exposed to prevailing world market prices;
   b. anticipated new investment in drying plants over the next few years should be able to incorporate the latest energy and operational efficiencies, which will make the industry cost competitive, at least in the northern hemisphere; and,
   c. Ireland's status as a major cost-effective manufacturer of consistent quality,

Cheese exports

Ireland has benefited from the considerable growth in UK Cheddar cheese imports (**Figure 1**), but this development has attracted new market entrants supplying Cheddar from within the EU, e.g., France and the Netherlands; hence, the need to maintain a very efficient and competitive Irish Cheddar cheese manufacturing base in Ireland.

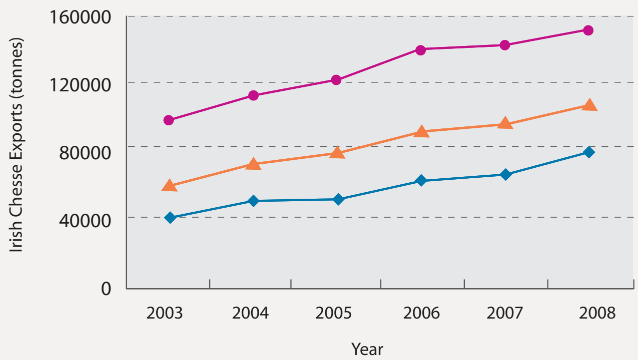

FIGURE 1: Cheese exports from the Republic of Ireland 2003-2008: total cheese exports (●); total cheese exports to the UK (▲); and, Cheddar cheese exports to the UK (◆).

commodity Cheddar cheese needs to be underpinned so as to minimise import threats from European mass producers of other cheese varieties that could substitute for Cheddar, especially in the UK market.

2. New initiatives in cheese and cheese ingredient manufacture based on achieving technological advantage, which would enable Ireland to engage in growing market opportunities within the single market.
3. A greater focus on the components of milk and their added-value potential in conjunction with casein and casein/milk fat (cheese) utilisation. Many of our dairy companies engaged in whey processing do so as a consequence of their involvement either in cheese or casein production. Maximising the value of products from whey streams is therefore important in ensuring overall profitability. Of particular relevance is the fractionation of whey into added-value components, which are finding increasing application in the expanding whey-based nutritionals market, especially in the USA.
4. The advent of new technology for the separation of casein in its native form from milk coincides with the decline in production of, and prices paid for, acid/rennet caseins. Native casein, also called phosphocasein, differs in functionality to traditionally-produced casein and presents dairy technologists with new opportunities in food processing and product formulation. Free of subsidies and the 'industrial use' origin attached to traditionally-produced acid casein, native casein is being recognised as a legitimate dairy ingredient that does not pose a threat as a milk substitute within the EU – a characteristic that clouded the use of traditional casein/caseinate-based ingredients. Moreover, the technology for separation of native casein from milk provides a high quality, 'clean' whey stream that is more suitable than cheese whey for the manufacture of nutritional products or fractionated whey products.

Aligning advances in native casein adaptation with market opportunities in cheese is the subject of a major research initiative at Moorepark Food Research Centre. Novel native-casein based ingredients are reconstituted into concentrated reassembled milks that are converted directly into cheese without whey secretion (**Table 1**). This approach poses considerable challenges for optimising rehydration and controlling viscosity during reconstitution. This new platform technology is ideally suited to engineering new cheese functionalities, and therefore to exploitation of the use of cheese as an ingredient in the food formulation and service sectors.

TABLE 1. New Moorepark approaches for optimising product mix for the Irish dairy industry

Cheeses

Commodity cheeses

- Minimising production cost while retaining quality consistency, via optimising milk production and processing systems.

New high-moisture ingredient cheeses

- Targeted primarily at food service, based on new platform technology and novel milk protein ingredients via exploitation of protein/mineral and protein/polymer interactions; and,
- adding bio-functional components for niche markets.

Ingredients

New improved dairy protein-based ingredients

- Extending use of ingredients by optimisation of biopolymer (protein and/or carbohydrate) interactions; and,
- techno-functionality aligned to manufacture of ingredient cheese and optimised food formulation.

New improved bio-functional and nutritional ingredients

- Beverage applications and infant formula;
- milk-fat globule membrane/buttermilk extracts;
- milk-based oligosaccharides; and,
- bio-functional dairy proteins: modulation of glycaemia; gluten substitution, anti-tumour activity.

Conclusions

The answer to the question: 'Product mix – commodity or higher value-added products?' is that it is not an either/or situation for the Irish dairy industry, but that a co-existence of both options is required. Cost-competitive commodity dairy product manufacture will continue to be an important part of the product mix. Investment in new milk-drying plant to match the anticipated expansion in milk output will be essential to realise the benefits of scale and incorporate operational efficiencies at the design stage. An important decision is whether such plant is designed for a single product line or will incorporate additional flexibility to allow manufacture of a range of nutritional products. If not, then this opportunity may have to be addressed with the provision of separate processing and drying facilities, which meet the higher specifications and standards demanded by nutritional product customers. Such a development would build on the unique relationships that Irish dairy companies have developed in supplying milk to multinational infant milk formula manufacturers operating both within and outside Ireland. The commercial development and incorporation of α-lactalbumin into infant formula began as an innovative output from Moorepark's research programme and points the way for further such added-value opportunities. The industry's capability for the extraction of added-value components from whey in the form of techno-functional and nutritional ingredients is already at an advanced level. However, we can expect to see the benefits of advances in current food research being brought to bear by the use of these ingredients in the development of new functional foods. Moorepark's current research initiative aimed at revolutionising approaches for the development of ingredient cheeses could re-launch Ireland's prospects of becoming a significant player in cheese markets that are becoming increasingly segmented and where we can exercise technological advantage over competitors.

There is scope for the further mining of milk as a source of bioactive components and the recently-launched industry-led Foods for Health Ireland (FHI) project brings this a step further through a major collaborative research effort. Moorepark assumes a lead role in the technology transfer phase, which will involve translation of scientific outputs from the laboratory into bio-functional ingredients through adaptation of pre-commercial scale-up processes (**Table 1**). Complementary technologies such as encapsulation will also be researched within FHI in order to create targeted delivery systems.

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 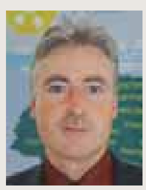  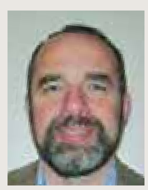

Increasing the availability of genetically superior heifers for dairy expansion

A shortage of high EBI heifers would have serious consequences for profitable dairy herd expansion in Ireland. STEPHEN BUTLER of Teagasc, Moorepark, and MICHAEL DISKIN of Teagasc, Athenry, explain the importance of breeding to AI dairy sires.

Current situation

The breeding programme to supply replacement heifers in dairy herds should ensure that every replacement heifer is genetically superior to the average cow in the herd. This is essential to ensure that the herd average genetic merit (or Economic Breeding Index; EBI) is continuously improving. Hence, all the replacement heifers coming into the herd should be sired by genetically superior AI bulls. In an expansion scenario, the number of replacement heifers sired by genetically superior AI bulls must be greater than the number of dairy cows that are removed from the herd due to culling and death. In Ireland, we are not currently achieving this objective, and the consequent shortage of high EBI heifers will present a significant barrier to profitable dairy herd expansion in the post-quota era. The total number of female calves born to a dairy bull (dairy AI and dairy stock bulls combined) in 2007 was 255,777. The total number of dairy females over 24 months of age that were slaughtered or that died in 2007 was 261,330. These figures clearly indicate that current dairy cow culling rates match or exceed the supply of dairy replacement heifers and, as a result, there is currently no scope for a rapid expansion of the national dairy herd. The Irish Cattle Breeding Federation database also reveals that of 224,204 dairy heifers born in 2007 (almost 90% of total born), only 53% were sired by an AI bull. In recent years there has been a modest increase in AI usage, primarily in the form of DIY AI (**Figure 1**), but overall AI usage remains unacceptably low compared to international competitors.

Increasing the use of dairy AI

The first step to remedy this situation is to increase the proportion of the herd that becomes pregnant to high genetic merit dairy AI sires. With good submission rates (~90%) and reasonable conception rates (~50%), six weeks of AI use at the start of the breeding season would result in 70% of the milking herd becoming pregnant to high genetic merit bulls. Maiden heifers should also be bred to high genetic merit (easy-calving) AI bulls. This ensures adequate replacements for cows culled from the herd (20-25%), and surplus heifers can be maintained in the herd for expansion, or sold as high genetic merit replacements in a buoyant heifer market. An additional advantage is that this also allows an expanding dairy farmer to maintain a closed herd (see article on biosecurity, p.23). The recommendation is to use the minimum number of dairy AI straws that will provide you with your targeted number of heifer replacements in 2012 (**Table 1**). Clearly, herds with low conception rates require more AI straws than herds with

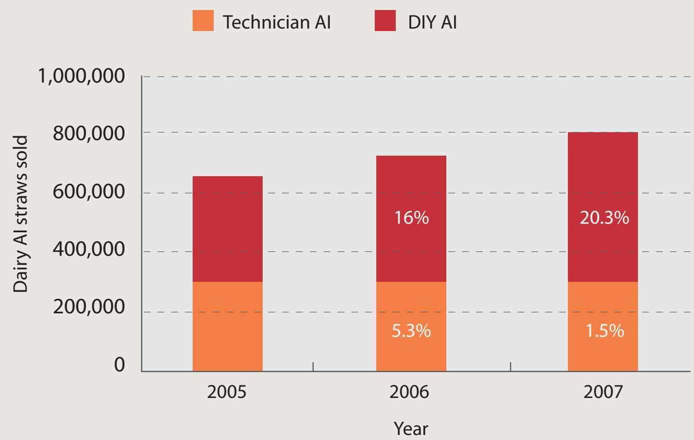

FIGURE 1: Sales of dairy AI straws through technician AI services and to dairy DIY AI operators. The percentage increase over the previous year is indicated within each bar. Note that the figures for the technician service are actual inseminations, but the figures for DIY AI operators represent semen straw sales only. (Source: DAFF.)

TABLE 1. Number of semen straws required to produce a replacement heifer as affected by herd conception rate and the number of straws required to provide 20 lactating heifers.

Herd conception rate	Number of straws required	Number of straws required for 20 replacement heifers*
40%	6.22	140
50%	4.98	110
60%	4.15	96
70%	3.55	80

**Includes an added 10% to allow for the vagaries in the proportion of heifer calves born, which is particularly important in small herds.*

high conception rates. The ability to accurately identify when a cow is in oestrus will play a central role in increasing the proportion of the herd becoming pregnant to AI bulls. There are two principal mechanisms to do this. The first involves improving oestrus detection. The second involves controlling the timing of oestrus and/or ovulation to facilitate AI use.

Improving heat detection

There is a considerable body of evidence to indicate that the use of heat detection aids improves efficiency of oestrus detection. A study was carried out in 2007 to compare four heat detection aids. The aids were: (i) FIL tail paint; (ii) Paint stick; (iii) CheckMate mount detectors; and, (iv) Estrotect scratch cards. A total of 750 cows in eight herds were used in the study. The CheckMate and Estrotect devices were described in detail in a previous issue of *TResearch* (Volume 2 (2): 8-10). The FIL tail paint is an oil-based fluorescent paint, and comes in a bottle with an applicator. Paint Stick is a device containing hard paint on a stick, and is used like a crayon. The fertility results at the end of the season showed no major difference between any of the aids. The bottom line is that there are a variety of aids available, and dairy farmers should choose one that suits their own system.

Automated heat detection

During oestrus, cows increase physical activity. In April 2007, 173 cows in Moorepark's Ballydague farm were fitted with Dairymaster's MooMonitor collars. The collar contains an accelerometer device that continuously monitors movement in all directions, and the information is automatically retrieved at each milking. The activity data for each cow is then compared against her activity over the preceding number of days, and cows with an abrupt rise in activity are flagged for examination. At the end of the study, heats identified by the MooMonitor activity meter were compared against heats confirmed by milk progesterone data. During the monitoring period, the MooMonitor device correctly identified 82% of the heats that occurred, and had an error rate of 6.8% (i.e., seven out of 100 cows incorrectly identified as being in heat). These are encouraging results, which indicate that the system is capable of operating well in a pasture-based system.

Heat synchronisation

A large trial was carried out on eight commercial dairy farms in spring 2008 to assess the potential of cow synchronisation to reduce the interval from mating start date to conception. One of the protocols synchronised oestrus (heat), with insemination based on observed oestrus, and two protocols synchronised ovulation and allowed fixed-time AI without reference to oestrus. The synchronisation treatments resulted in shorter calving to service intervals and shorter calving to conception intervals. An obvious advantage of the fixed time protocols was that they facilitated increased use of AI and thus would increase the proportion of replacement heifers sired by high EBI AI sires. Further analysis of this dataset is planned to determine the cost–benefit of the different synchrony protocols.

Sexed semen

Semen containing only X-bearing sperm is referred to as "sexed" semen; if sorting was 100% accurate, use of "X-sorted" semen would result in heifer births only. The technology for sorting X and Y sperm is called fluorescence activated cell sorting. Currently, this technology has two principal limitations. Firstly, the machines are expensive and sorting speed is slow, resulting in a substantial increase in the price per straw relative to conventional semen. Secondly, sperm are damaged during the sorting process, and conception rates are consequently reduced. In maiden heifers, conception rates with sexed semen are generally reduced by approximately 20 percentage points relative to unsorted semen. Because of the typically poorer conception rates in lactating cows, the use of sexed semen is not recommended in these animals. The technology holds great promise to revolutionise breeding in the dairy industry, but the uptake of sexed semen is currently limited due to price, reduced conception rates, and lack of availability of desirable sires. Currently, no Irish AI centre has a sorting machine.

Conclusions

The single most important way to increase the supply of high genetic merit dairy herd replacements is to breed more cows and heifers to AI dairy sires. There is significant scope on many farms to breed more replacement heifers to proven AI sires. Furthermore, because of the higher conception rates achieved in heifers, there is a greater likelihood of a heifer replacement being obtained per straw used than with lactating cows. There are useful technologies that facilitate the increased use of AI through improving heat detection efficiency, and synchronisation of oestrus or ovulation; the latter allowing fixed-time AI without reference to heat. "Sexed" semen should only be used in maiden heifers.

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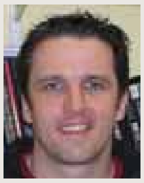


Profitable expansion requires maximising genetic improvement

As dairy herds expand, labour input per animal will decline, meaning that the cow of the future must be 'easy care' as well as being capable of producing large quantities of milk solids from a finite land base. Animal breeding research at Moorepark is focused on breeding this type of cow.

Breeding made easy

The benefits of using selection indexes to identify genetically superior animals date back to 1943. In 2001, Teagasc Moorepark was involved in the development of the Economic Breeding Index (EBI) for dairy cattle, which included performance traits related to revenue and costs. The goal of the EBI was to identify animals whose progeny will be most profitable under future Irish production systems. Today, the EBI includes 15 traits related to milk production, fertility, calving performance, efficiency, beef performance, and health. Animals excelling in all attributes receive high EBI figures.

A national breeding programme

The choice of AI sire available to individual farmers annually is determined by the genetic merit of young bull calves that enter a national breeding programme. Having a world-class index for identifying the best animals is futile without a constant supply of high EBI bulls for breeding. Furthermore, for sustainable long-term genetic gain, the maintenance of genetic diversity is also crucial. In 2008, Teagasc Moorepark, in collaboration with the ICBF and the National Cattle Breeding Centre, initiated research on developing the logistics and mathematical methodology for generating matings between genetically elite dams and sires to produce genetically elite animals, while simultaneously minimising the accumulation of inbreeding in the Irish population in the future. The methods developed were implemented by the National Cattle Breeding Centre in 2008.

Genomic selection

Genomic selection is based on the simultaneous selection for many thousands of genetic markers that densely cover the entire genome, made possible by developments in high throughput genotyping platforms. In expectation of the importance of upcoming molecular technologies in animal breeding, Teagasc started collecting and storing DNA from animals some years ago, as outlined in the last issue of *TResearch* (Volume 4 (1): 18-19). Genotyping of over 1,100 proven bulls began in January. The development of software to handle and analyse the resulting data began at Moorepark in July 2008 and the methodologies developed were implemented in January 2009.

To test the methodology, genotypes of the older proven bulls were used to estimate the effect of the genetic markers and these predictions were applied to the genotypes of the younger proven bulls. Since we already knew the genetic merit of all bulls based on traditional genetic evaluation procedures, we could easily quantify how good our predictions were, based solely on the DNA of each animal. Results showed a benefit of using genomic selection to more accurately identify genetically elite animals.

Genomic selection has the potential to increase genetic gain in Ireland by 50%. The first official estimates of genomic breeding values were generated in January 2009 using software developed at Moorepark, making Ireland the second country in the world to do so. The average EBI of the bulls on the Active Bull List increased 500% over previous annual trends. Reliability of predicted genetic merit increased by up to 18 percentage units.

Crossbreeding

The growing interest in crossbreeding in Ireland is being fuelled by the positive results emanating from the crossbreeding studies at Moorepark, coupled with farmer realisation that high output per hectare in an Irish context requires a robust cow, capable of high output from a high forage diet and high reproductive efficiency/survival. As a mating strategy for dairy cows, crossbreeding is not a novel concept. Studies evaluating crossbreeding date back many decades. However, with the exception of New Zealand, crossbreeding has

not been popular. This lack of popularity is most likely due to the historical divergence in yield potential between the available alternative breeds and the Holstein. Fundamentally, a successful crossbreeding strategy aims to: 1) introduce favourable genes from another breed selected more strongly for traits of interest; 2) remove the negative effects associated with inbreeding depression; and, 3) capitalise on heterosis or hybrid vigour, where crossbred animals usually perform better than that expected based on the average of their parents.

Moorepark crossbreeding studies

Two studies to evaluate/demonstrate the potential merits of dairy crossbreeding under Irish conditions have been ongoing at Moorepark. One study is evaluating crossbreeding with the Norwegian Red, a breed that has been selected with an index not dissimilar to the Irish EBI since the 1960s. This study was run across 46 commercial dairy herds. The second trial, based at the Ballydague research farm, is evaluating Jersey crossbreds.

The results to date strongly suggest that using a Norwegian Red or Jersey sire will deliver high profit to Irish farmers. In both cases, production potential is not compromised by crossbreeding and reproductive efficiency and survival of the crossbred cows is markedly improved compared to the Holstein-Friesian cows on trial. The advantage from crossbreeding is likely to be substantial where the EBI, or more specifically the fertility sub-index, is low. However, farmers will benefit from hybrid vigour even with high EBI herds. The ICBF has calculated that hybrid vigour is worth over €50 per lactation. This value is not included in the published EBI of alternative breed sires. So, in essence a farmer can expect greater performance than that explained by the EBI of these sires. The value of €50 is based on an average value for all crossbreds in the national database. It is likely to be different depending on the breeds being crossed.

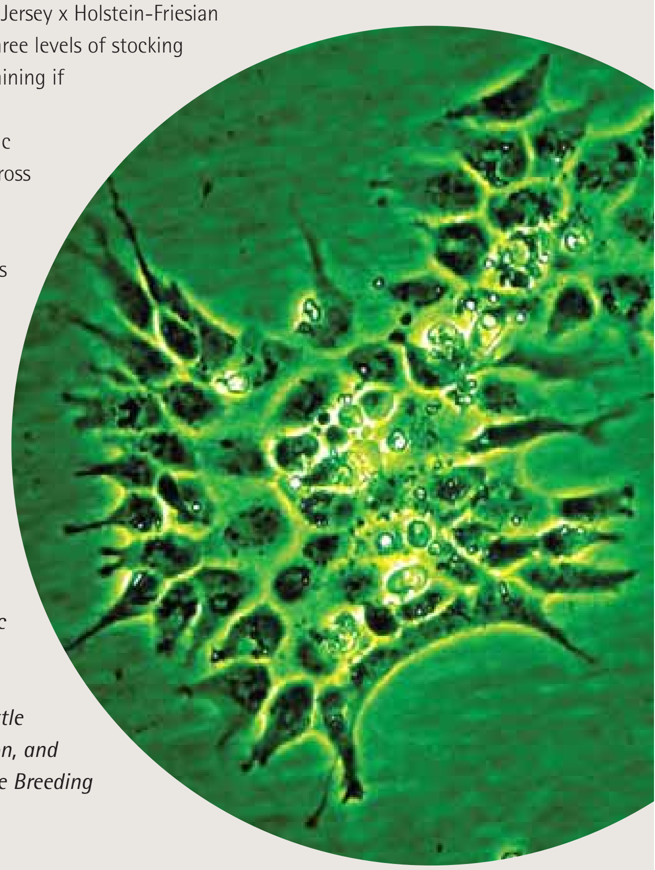
Sire selection and associated issues

At present a critical limitation, not only for the Jersey and Norwegian Red but for many alternative breeds, is a lack of data on these breeds. Given the positive outcome of the current research at Moorepark, it is anticipated that the use of both Jersey and Norwegian Red in Ireland will continue, thus increasing the data available for domestic and international genetic evaluations.

The choice of breed and crossbreeding strategy will depend on issues such as current herd makeup, production system, and milk payment system, as well as other potential avenues of revenues (e.g., male calf and cull cow sales), the costs of production or simply personal preference. Based on the current findings, crossbreeding with Jersey or Norwegian Red is likely to result in improved herd productivity when compared to Holstein-Friesian. This is because, under seasonal production circumstances, differences in production potential are not likely to be expressed because actual yields are governed by calving pattern and the proportion of cows surviving to maturity.

Future research

Continuous development of the EBI is one of the main research topics at Moorepark since any developments in animal breeding are futile without a pertinent breeding goal. Traits of particular interest going forward are animal health and efficiency. Research on genomic selection at Moorepark will focus on investigating the potential to develop a less expensive, smaller SNP panel, and methodologies to account for animals of different genotypes with different allele frequencies and allelic substitution effects. Moorepark is part of a large consortium to develop free software for genomic selection (http://www.genomicselection.net), an international collaboration to develop across-country genomic evaluations, and a Framework Programme 7 collaborative project (http://www.robustmilk.com) and Marie Curie network (GREENHOUSEMILK) to develop phenotypic and genomic tools to further increase the rate of genetic gain. Research on amending the Irish national breeding programme is also underway in light of technological advances in genomics. Research at the Teagasc Ballydague site over the next few years will focus primarily on two key issues: 1) evaluation of the performance of Holstein-Friesian, Jersey and Jersey x Holstein-Friesian crossbreds across three levels of stocking rate; and, 2) determining if differences in production/energetic efficiencies exist across these three genetic groups. The Ballydague farm has been restructured and the study to evaluate these two key issues is now in progress.



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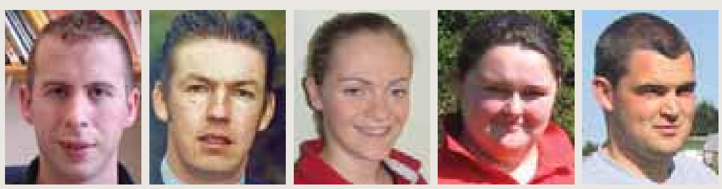

Dairy expansion – an opportunity for the environment?

STAN LALOR, JOHN MURPHY, and ROGIER SCHULTE discuss strategies that will allow dairy farmers to expand, while continuing to protect the farm's natural resources, and complying with environmental regulations.

Farming activities have long been heralded as being a critical developer and shaper of the rural landscape and environment that we enjoy in Ireland today. Indeed, the intimate synergy that exists between farmers' requirements and the environmental resources of soil, water, air and biodiversity, is as much a driver of sustainable agriculture in this country now as it ever was.

Historically, farmers engaged in resource protection solely out of necessity to sustain their production capacity through generations. However, what has changed in recent times is the way in which environmental protection must be implemented at farm level: we have now entered a new era of legislation driven by environmental protection at a global and European scale, such as the Water Framework Directive (WFD), and the Kyoto and post-Kyoto agreements.

Water quality legislation

The WFD is an important piece of EU legislation that was adopted by the European Commission in 2000; it aims to bring together and integrate the many existing directives related to protecting water quality, such as the Groundwater Directive (1980), Nitrates Directive (1991), Drinking Water Directive (1998) and Bathing Water Directive (2006). It commits all Member States to ensure that all water bodies (i.e., groundwater, surface water, coastal waters) and groundwater-dependent terrestrial ecosystems are of at least "good status" by 2015. The measures already in place for the Nitrates Directive will be the main agricultural tool in the WFD toolbox. However, it cannot be ruled out that, on a regional basis, additional measures may be required. Areas where these are most likely include: 1) catchments with waters that are highly sensitive to eutrophication; and, 2) areas that are highly vulnerable to nutrient loss (Schulte *et al.*, 2009a).

Greenhouse gases

Climate change has been identified as the most significant and threatening global environmental problem facing humanity today. The Kyoto Protocol was the first major international agreement to reduce emissions. Under it, the EU agreed to an 8% reduction by 2012 and, as part of the EU target, Ireland agreed to limit the growth in greenhouse gas (GHG) emissions to 13% above 1990 levels by 2012. More recently, the 2008 December Council meeting of EU leaders agreed to a further reduction in GHG of 20% by 2020, or 30% if a new global agreement is reached. Over 50% of agricultural emissions are methane (CH_4) from enteric fermentation, and most of the remainder is nitrous oxide (N_2O) released from soils (O'Mara, 2009). The final decision on the reductions required by 2020, and agreement of the required contribution of the agriculture sector in Ireland to our national emission reduction, will be of critical importance in planning the expansion of the dairy industry.

Towards solutions

With the drive for increased productivity that will arise as quotas are removed comes an opportunity for improving environmental sustainability. More efficient systems will require more efficient input utilisation and resource protection in order to ensure their economic sustainability. In this light, the challenge facing the dairy industry is to develop farm management strategies that allow farmers to capitalise on the economic opportunities, and at the same time continue to protect the farm's natural resources.

Since 2005, Teagasc has been intensely investigating a wide range of technologies that have potential to facilitate this sustainable expansion (Schulte, 2006), with particular focus on the following:

Nutrient efficiency

Applied nutrients not converted into product represent an economic loss to the farmer and, in the case of nitrogen (N) and phosphorus (P), a potential threat to the environment through N and P loss to water, and ammonia and N_2O loss to air. Strategies to reduce nutrient surpluses are being developed, which focus on fertiliser uptake efficiency through revised rates and timings, the use of clover, and nutrient recycling within the farm through optimal organic manure management (Coulter and Lalor, 2008). For example, fertiliser N input on the Teagasc Curtins farm since 2001 has been reduced by about 20% while maintaining milk output per hectare (Horan, 2009).

Soil N dynamics

Recycling of nutrients can be further augmented by manipulating the N dynamics in soils. Over the last four years, Teagasc has developed the capacity to track the behaviour of soil N pools in grassland systems, using ^{15}N labelling of fertiliser, grass and manure. Potential applications of this technology to improve our understanding of soil processes include the use of urease and nitrification inhibitors. These are soil amendments that reduce the biological conversion of soil ammonia, which is available for uptake by grass, to nitrite and nitrate, which can be leached to groundwater or alternatively be converted further to N_2O, a potent GHG. Teagasc, in conjunction with NUI Maynooth, is now developing application methods that maximise the effectiveness of these inhibitors.

Grazing management

The opportunity for dairy expansion in Ireland is highly dependent on low-cost production platforms based on extended grazing. However, autumn grazing on freely drained soils can lead to increased nitrate losses, due to the combination of

concentrated deposition of N in urine patches, increased drainage, and relatively low N uptake by grass in this period. As a solution, Teagasc is developing on/off grazing strategies, where cows can be grazed for reduced periods each day in autumn. Initial results suggest that 95% of grass intake can be achieved in two three-hour grazing periods per day (Kennedy *et al*., 2009). In this scenario, most of the urine and dung N is captured in the slurry rather than being deposited directly in the field.

Those nutrients in slurry can then be applied at other times, such as spring, when grass N uptake is higher, thereby reducing the potential for leaching losses.

GHG production per kg of milk can be substantially reduced from the level produced by the average cow nationally by adopting the efficient grass-based system of milk production promoted by Moorepark (Lovett *et al*., 2008).

Dairy systems

The post-quota era of dairy farming will change how farmers analyse their business. Previously, since the amount of milk a farm could supply was restricted by quota, the focus was on maximising the return per unit of milk produced. However, as an unrestricted supply scenario unfolds, the emphasis will move towards maximising the return per unit area. This is likely to result in a continuing emphasis towards high output per hectare systems, driven by higher stocking rate, greater output per animal and efficient production and utilisation of grazed grass. Teagasc is currently evaluating system strategies for achieving higher productivity targets. Options available for increasing the milk output per hectare include increasing either stocking rate, milk output per cow, or both.

The path forward

Implications for the environment will require consideration when planning dairy expansion, but it should not be a limiting factor to the industry's potential if managed correctly. Lack of environmental planning has the potential to cause problems in the future. However, Teagasc research is indicating that with the appropriate strategies, environmental requirements as they are currently understood can be met, and sufficient protection of our resources to ensure continued productivity in the future can be delivered. While our understanding of these environmental challenges and the potential solution options is developing rapidly, there is still a considerable body of work to be done to meet the challenges ahead. In particular, a better understanding of the soil specificity of nutrient uptake and loss potential is essential to provide farmers with the information to allow them to choose options that will be effective in their individual situation, and likewise, avoid the cost of implementation of measures that would be ineffective within their resources and system. Practical strategies to mitigate GHG production in our dairy systems will be required in the near future if the proposed reductions are to be achieved.

References

Coulter, B.S. and Lalor, S. (editors). (2008). *Major and micro nutrient advice for productive agricultural crops.* (3rd edition). Teagasc, Johnstown Castle, Wexford.

Horan, B. (2009). 'Grassland Management and Fertilizer Use on Intensive Dairy Farms'. In: **Lalor, S.** (editor). Fertilizer Association of Ireland, Spring Scientific Meeting 2009. Publication No. 44, pages 2-15.

Kennedy, E., Curran, J., Murphy, J.P. and O'Donovan, M. (2009). 'Overcoming limitations affecting the number of grazing days per year achieved by dairy cows'. Agricultural Research Forum 2009, Tullamore.

Lovett, D.K., *et al.* (2008). 'Greenhouse gas emissions from pastoral based dairying systems: The effect of uncertainty and management change under two contrasting production systems'. *Livestock Science*, 116: 260-274.

O'Mara, F. (2009). 'Climate change and agriculture'. *TResearch*, 4 (1): 38-40.

Schulte, R.P.O. (2006). Beyond the Nitrates Directive: new challenges in nutrient research. *TResearch*, 1 (1): 10-13.

Schulte, R.P.O. *et al.* (2009a). 'The Water Framework Directive – troubled waters or water under the bridge?' *TResearch*, 4 (1): 35-37.

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Low fixed cost expansion options with increased labour efficiency

A Moorepark labour study highlights where efficiencies can be achieved.

The Irish dairy industry has significant potential for expansion in the post-quota era. To facilitate this expansion there will be a requirement for: (1) increased labour efficiency due to increases in herd size; and, (2) low-cost wintering facilities to accommodate additional dairy cows. Furthermore, with an increase in cow numbers, a greater number of replacement heifers will be born and also have to be catered for.

Increase labour efficiency

Table 1 shows the relationship between herd size and labour efficiency in Irish dairy herds. This Moorepark study showed a peak daily labour input of 10.1 hours/day in March and a trough of 7.3 in December with a herd size of 50 to 80 dairy cows. The efficiency of labour input increased significantly with increased herd size. Milking was the most time-consuming task, accounting for over 30-35% of total labour demand, followed by calf rearing. Labour efficiency on dairy farms will have to increase significantly in the future if average quota size increases to 485,780l, as suggested in the Prospectus consultancy report for the 'Strategic Development Plan for the Irish Dairy Processing Industry' (www.prospectus.ie). Labour efficiency on dairy farms is significantly influenced by: (1) the system of milk production; (2) efficiency of the milking process; and, (3) the calf-rearing system.

System of milk production

Pasture-based systems of milk production are the most labour-efficient systems (**Table 2**). New Zealand dairy farms are predominantly pastured based and are characterised by large herd size, modest milk production/cow, low concentrate input, high stocking rate and a high number of cows per labour unit. In contrast, confinement milk production systems are characterised by smaller herd sizes, significantly higher milk production/cow and concentrate input with lower stocking rates and number of cows per labour unit. Grass-based systems, when expressed in milk solids per labour unit, are more labour-efficient than confinement systems of milk production. Compact spring calving with increased proportions of grazed grass in the feed budget will increase labour efficiency in Irish dairy farms.

Efficiency of the milking process

The Moorepark labour study showed that proportionally 0.33 of the net labour input per day in a dairy enterprise was associated with the milking process (herding, milking and washing). This represented an average of 3.9 hours of labour per day between March and November. Milking represented 0.64 of the milking process time. In the future, apart from restricted land resources, milking facilities are likely to be an important factor in the limitation of milk production. Having a milking unit with a large output in terms of milk produced per hour will be necessary. A detailed investigation of milking practices and facilities indicated that the main time-escalating element was inadequate number of milking units, followed by restriction in cow flow due to narrow doorways and the fact that the exit gate could not be operated from any point in the pit. In the least efficient farms, 68% of the herds had >7 cows milked per unit, while in the most efficient farms only 8% milked >7 cows per unit. In the least labour-efficient dairy farms, 30% operated exit gates from the pit, while in the most efficient, 68% operated exit gates from the pit.

TABLE 1. The relationship between herd size and labour efficiency in Irish dairy herds.

	Herd size group		
	Small	Medium	Large
No. of cows	44	62	147
Milk quota (litres)	236,000	296,000	745,000
Hours/cow/year (hr/cow/yr)	49	42	29
Milking as a percentage of total time (%)	35	32	30
Full labour costs (c/l)	10.2	9.7	6.4
Labour as a percentage of total costs (%)	35	31	24

TABLE 2: Physical characteristics of dairy farming systems in various countries.

Variable	New Zealand	Australia	Ireland	US grazing	US confined
Farm size (ha)	103	229	25	80	168
Number of cows	271	312	47	64	115
Milk yield/cow (l)	3,678	4,800	4,526	7,779	10,243
Fat + protein/cow (kg)	323	350	343	544	832
Replacement rate (%)	18	15	19	-	33
Concentrate (kg/cow)	150	400	920	-	4,500
Stocking rate (cows/ha)	2.67	2.48	1.9	0.80	0.68
Cows/labour unit	97	80	44	-	40

Calf-rearing system

With increased numbers of dairy cows, higher numbers of replacement heifers need to be carried to maintain herd size. These animals have to be managed from the extremely labour-intensive pre-weaned calf to the pre-calving heifer stage. Labour requirements for calf care peak during the calving period, with a high demand for labour continuing for up to 12 weeks. An ideal scenario would be to minimise the labour input required during this time, yet not compromise calf health and welfare. The Moorepark labour study found that the labour associated with calf care was influenced by herd size and calf feeding system. From **Table 3**, it is evident that once-a-day feeding requires the least labour input (23 sec./calf/day); in addition, calf weight at 77 days is not adversely affected. Additional studies are currently being undertaken at Teagasc Moorepark to establish if outdoor rearing of calves from one week old will further reduce the labour requirement and capital cost associated with calf rearing.

TABLE 3: Effect of calf feeding system on daily labour input, calf weight and weight gain.

	Automatic feeder	Once daily with teats	Twice daily with teats	Twice daily with trough
Total calf care time incl. vet. time (sec./calf/day)	38	23	36	27
Calf weight at 77 days (kg)	95.0	94.8	93.2	90.5
Calf weight gain per day (kg)	0.70	0.79	0.80	0.65

TABLE 4: Capital and annualised wintering costs (€/cow) with both low cost and conventional winter accommodation systems.

	Conventional	Low cost accommodation	
		Earthen-lined pad and lagoon	Plastic-lined pad and lagoon
Capital cost	**3,000**	**700**	**1,000**
Annualised costs/cow			
Silage	135	135	135
Depreciation	159	37	53
Interest	116	27	38
Labour	44	44	44
Slurry spreading	15	20	20
Bedding		20	20
Total cost/cow/year	**469**	**283**	**310**

Based on 20-week slurry storage and 34mm/week winter rainfall.

Providing over-winter accommodation for increased numbers of replacement heifers is also an economic burden on the dairy enterprise. The development of systems based on forage crops, such as kale, for weanling heifers, reduces the costs associated with conventional housing systems. Furthermore, given the cost of rearing replacement heifers it is imperative that target weights are achieved throughout the rearing process. Kale, a brassica crop, is approximately 1.05UFL/kg DM and costs 13.3c/kg DM, while grass silage, the more traditional winter feed, is approximately 0.8UFL/kg DM and costs between 16.1 and 17.1c/kg DM. Thus, offering kale, a higher energy cheaper feed, to the heifers during the winter period will ensure that they reach target weight while simultaneously reducing associated costs.

Low-cost wintering accommodation

A major advantage of low capital cost wintering systems is that they allow farmers with limited resources to put facilities in place and thereby gain control over the expansion of their business. Recent innovations in using out-wintering pads (OWP) and earth bank tanks have the potential to reduce housing and effluent management costs while providing robust facilities for dairy herd management. Any alternative wintering system to conventional facilities needs to be welfare-friendly, have a low capital cost, low running cost, be labour-efficient and environmentally secure.

An OWP is an alternative method of accommodating cows to conventional sheds. The OWP provides a woodchip-based drained lying area outdoors for the animals. The OWP is operated at a much lower stocking rate than conventional accommodation. Underneath the drainage system the effluent is contained by a soil or plastic liner and it is collected and stored before being recycled onto a suitable crop. The woodchip bed retains most of the nutrients produced by the livestock and these woodchips are also recycled onto a suitable crop such as grass. **Table 4** outlines the capital and operating costs associated with alternative winter accommodation and slurry storage systems. The capital cost of the three systems compared in **Table 4** includes the cow accommodation and slurry storage and concrete slab for storing silage. The systems compared include conventional housing and slurry storage (€3,000/cow), earthen-lined pad and lagoon (€700/cow) and plastic-lined pad and lagoon (€1,000/cow); all three costs include an outlay of €150/cow for silage storage. The results show that both of the low cost options cost substantially less than the conventional housing option. When current fluctuations in milk price and increased potential for expansion in milk production are taken into account, the conventional housing option becomes non-viable as it may end up causing liquidity problems.

There are challenges, in terms of cost reduction and labour efficiency, facing dairy farmers over the coming years. However, technologies to help farmers overcome these challenges are available and their adoption will ensure the maximisation of their business profitability.

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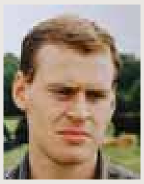
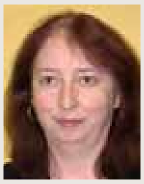



Importance of producing high quality milk

With industry requiring increasingly high quality standards, especially for export markets, BERNADETTE O'BRIEN, TOM BERESFORD and FINOLA McCOY outline areas where particular attention should be paid.

The production of milk in Ireland is based mainly on grazed grass. This leads to greater seasonality of milk supply, which in turn inhibits the variety of dairy products that can be processed in Ireland. Milk processing is very important to the Irish economy. Cheddar cheese represents a significant industry and Ireland has also become one of the world's leading producers of infant milk formula. The production of milk powders, butter, cream liqueurs and chocolate crumb is also important. However, in order to produce such a range of products of top quality that can command premium prices, high quality milk has to be produced as the primary raw material. Therefore, a key objective of the Moorepark Dairy Production and Food Research Centres is to promote and conduct research into the efficient production of milk of good composition and processing quality. The programme currently in place addresses milk composition, somatic cell count (SCC) and mastitis, hygiene and residues. This strategy incorporates both new approaches to continuing problems (e.g., Euro milk programme addressing milk SCC) and solutions to new problems (e.g., trichloromethane [TCM] residue in milk). Funding for this work is provided by the Dairy Levy. The many factors influencing milk quality do not act independently, but may be interdependent, e.g., cow nutrition, stage of lactation and health. The quality of farm bulk tank milk is mainly defined and dictated by gross and micro composition (of which enzymatic activity is an integral part), microbial contamination and presence of chemical residues.

Cow hygiene is most important.

Composition

The composition of milk, especially the concentrations of protein (casein), fat and calcium, has a major influence on several aspects of the product, e.g., cheese manufacture and, subsequently, cheese composition and yield. For example, Moorepark studies have shown that Cheddar cheese yield increases by ~0.22kg cheese/100kg milk for every 0.1% (w/w) increase in milk protein in the range 3 to 4.5%, while retaining the protein-to-fat ratio constant at 0.96.

Cow nutrition

Much research at Moorepark has demonstrated a clear link between milk composition and nutrition of the cow. Underfeeding of cows during the early spring lactation period compromises milk production, composition and processing characteristics. It has been demonstrated that supplementing the diet of spring-calved cows on grass silage or grazed grass with concentrate in late February to late April could significantly improve the cheese-making characteristics of the resulting milk.

Moorepark studies have shown that increasing herbage allowance in mid-lactation resulted in a significant increase in milk yield, and protein and casein concentration. Yield of low-moisture mozzarella cheese was also increased with increasing herbage allowance, and with concomitant increase in casein content, at a rate of ~0.35kg cheese/100kg milk for every 0.1% (w/w) increase in milk casein, where the milk casein-to-fat ratio is held constant at 0.9.

Moorepark studies have also shown that good composition and processing characteristics of milk from spring-calved cows can largely be maintained close to the end of lactation when good herd management practices are in place. The importance of cow diet in relation to quality milk production in late lactation within a spring production system needs to be highlighted, with particular reference to the positive economic consequence of milk production at that time of year. Dairy companies should consider the benefits of promoting quality milk production at this time of year through a competitive pricing structure and quality monitoring.

Stage of lactation

Dairy products manufactured in seasonal production systems can exhibit seasonal fluctuations in the yield, favour, storage stability and functionality. Stage of lactation also affects pH and degradation of some individual casein fractions in cheese during ageing. Lower conversion of fat and protein from late lactation milk into cheese is also observed; this results in small but economically important reductions in cheese yield. Seasonal changes in the concentration of functional constituents may also affect the ability to produce consistent high value dairy components, e.g., seasonal changes in β-lactoglobulin and α-lactalbumin concentrations may adversely affect the production of whey protein concentrate.

Udder health

Mastitis causes many changes to the chemical composition of milk by either: (i) damage to milk secretory cells, thus reducing the synthesis and secretion of various milk components; and, (ii) leakage of blood constituents into milk. SCC is one of the indicators of milk quality. Regulatory SCC levels and the adoption of mastitis control programmes have helped to improve the quality of milk produced worldwide. Milk SCC begins to affect product quality as levels go above 100,000 cells/ml. Milk with an SCC of >500,000 cells/ml has been shown to reduce moisture-adjusted cheese yield by 9%. A further impact of high SCC milk is that of increased moisture in cheese leading to decreased curd firmness and deterioration in organoleptic (sensory) properties. Uncontrolled increases in cheese moisture can also place the cheese outside of customer specification, with obvious serious economic consequences. Elevated SCC also causes problems with production of other dairy products, including butter and yoghurt, and thus reduction in SCC has become a key economic driver for milk processors, who now target low SCC milk supplies through introduction of penalty or bonus payments for high/low SCC milk, respectively.

Enzymatic activity

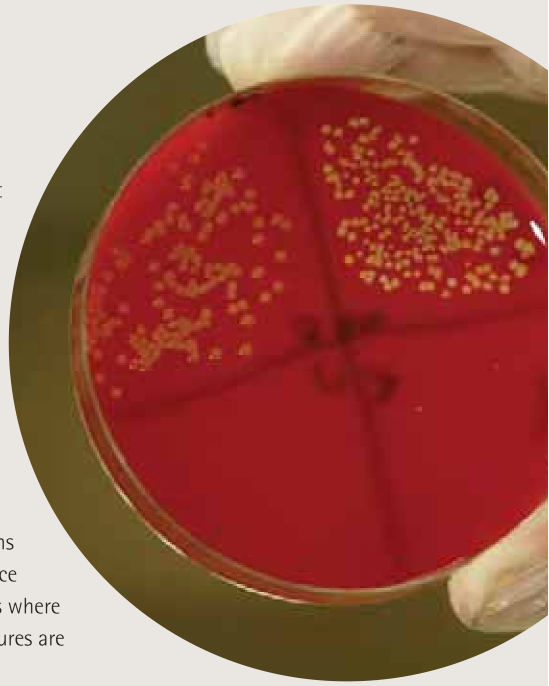
While much enzymatic activity during cheese ripening contributes positively to the sensory characteristics of cheese, other enzymatic activity can have a detrimental effect on cheese flavour and texture. Specifically, the enzyme plasmin is associated with casein micelles in milk and it degrades individual casein fractions, thus having an adverse effect on the quality of some dairy products. Plasmin activity increases as stage of lactation progresses. There is also an association between increased protein breakdown and high SCC milk. Protein and fat breakdown may also occur during cold storage of milk due to production of the enzymes by bacteria in the bulk tank.

Microbial contamination

Minimal microbial contamination of milk is important from two perspectives: (i) public health; and, (ii) dairy product quality. The main microbial pathogens that can be found in milk and that can have public health implications include *Listeria monocytogenes*, *Salmonella* spp. and *Campylobacter jejuni*. Additionally, the contamination of raw milk with *Bacillus cereus* can shorten the potential shelf life of pasteurised dairy products. The most important steps in providing milk of good microbiological quality are hygienic milk production and storage of that milk at the correct temperature within the correct time limit.

Residues

The most common residues that occur in milk are antibiotics, iodine and TCM. Milk is screened for antibiotic residues on a routine basis. Dairy products must be free of antibiotic residues in order to meet milk quality standards at home and abroad. The source of concern with regard to residues may be human health, export regulations for dairy products, or interference with the manufacturing process where yoghurt and cheese starter cultures are inhibited.



Identification of mastitis-causing bacteria.

High iodine levels in milk are currently having a negative impact on exports of dairy products from Ireland due to increasingly competitive standards. Currently, the most stringent standard in Ireland requires that iodine levels do not exceed 250mg/l milk. The highest levels of milk iodine are observed during winter months. The two main sources of iodine in milk are animal feed and iodophor products used for cleaning and disinfection.

TCM, otherwise known as chloroform, represents a further residue in milk. Presently, Irish dairy processors are experiencing difficulty in producing high fat products, in particular butter, that meet the TCM regulations of some importing countries. Thus, in order for Ireland's product to be competitive in the marketplace, non-detectable TCM levels are necessary in milk. Correct usage of detergents, together with sufficient rinsing, ensures minimal TCM levels.

Conclusions

A wide range of farming systems and practices are implemented in the production of milk for the manufacture of quality, high-value products. It is clear that the method of production has very significant implications. Thus, a comprehensive understanding is required of the relationship between farm management practices and characteristics of milk, and the subsequent processing of that milk into a product.

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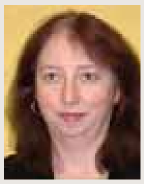

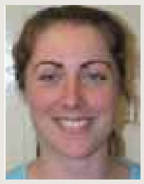

Milk processing, utilisation and pricing

A new Moorepark project will support the formulation of strategies for policy makers, milk processors and farm organisations in an era of substantial policy and market change, with the aim of securing the future viability of the farming sector.

Milk price in the EU is and will continue to be exposed to substantial fluctuation over the coming years as the supports available from the Common Agricultural Policy (CAP) recede. The EU market is no longer supported in the same way as it was pre-Mid Term Review; global developments on the world market are now the big influence within the EU. With the removal of EU supports, movement toward quota abolition and the opening up of the world dairy market, there is a real and urgent requirement at Irish farm and processor level to develop a business model that will maximise the overall industry profitability in the context of volatility in price. This can be achieved at farm level by focusing on cost reduction through increasing the number of cows per hectare and maximising the proportion of grass in the diet. At processor level, reducing costs and increasing product value by changing the product portfolio will be the main focus toward becoming more streamlined in the context of world dairy markets. Key areas directly affecting the sustainability of the dairy industry discussed herein are seasonality of milk supply as it affects profitability, milk supply profile and processing utilisation, product portfolio, expansion options and milk pricing. Also discussed are carbon mitigation strategies for the Irish dairy industry, plus a Teagasc-led Department of Agriculture, Fisheries and Food Stimulus Project developing strategies to maximise the potential of the dairy industry.

Seasonality of milk supply

Ireland's low cost seasonal milk production system has given Irish producers an advantage over their international counterparts. Grass-based milk production systems have a seasonal milk supply profile that results in substantially lower costs of milk production as well as strong insulation from milk price volatility. The relationship between costs at farm level, processing costs and product portfolio should decide the optimum calving date and spread in the Irish dairy herd. At processor level, product portfolio, capacity utilisation and processing costs are all affected by the seasonal milk supply profile. The advantage received through lower costs of production at farm level would have to be outweighed by product value and processing cost change for Ireland to change focus away from seasonal grass-based systems of milk production (**Figure 1**).

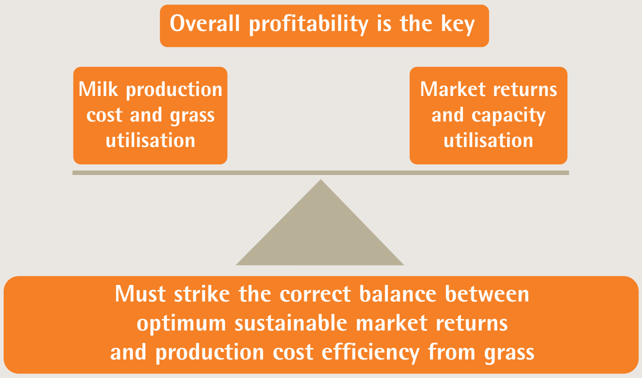

FIGURE 1: Seasonality and product mix implications.

Supply profile and processing capacity utilisation

Milk intake data derived from the Central Statistics Office for 1975-2008 showed that the peak month of May accounts for 14 to 15.5% of the total, while the trough month (January or December) accounts for 2 to 3%. There has been a steady decline in the percentage of milk supplied at peak between 1975 and 2008 (15.4 to 13.8%). The peak-to-trough ratio declined from a high of 8.8 in 1975 to 5.4 in 2008, while the processing capacity utilisation increased from approximately 53% in 1975 to 61% in 2008. The milk supply profiles are directly affected by the calving pattern of the national herd, the national mean calving date has been slipping year on year and is currently close to mid-March. The optimum mean calving date in a no milk quota environment will be closer to mid-February. A change in calving pattern at farm level would be associated with peak-to-trough ratios of less than 5% and capacity utilisation greater than 60%.

Product portfolio

The seasonal milk supply profile has a strong influence on the variety and timing of products being produced. Trends in whole milk utilisation from 1978 to 2007 illustrate that the Irish dairy industry has concentrated on the production of commodities. Ireland's product portfolio shows there has been a strong emphasis on butter. Ireland's dependence on butter has declined over the past 30 years in the order of 10%; however, this has been low compared to competitors. Ireland's dependency on commodity type products is well documented. Significant positive change has occurred in 2008 with a 30% increase in cheese production. The product portfolio of Irish dairy processors needs to be analysed in the context of market opportunities. Different markets should be analysed both within the EU and abroad to determine the potential markets for our expanding dairy products. This market outlook should then inform any future change in the product portfolio. A number of options are available to the dairy industry that need to be evaluated in relation to their costs versus the overall return to the industry:

Seasonalise the processing industry

Currently most dairy processors operate throughout 12 months of the year, working at close to full capacity for three to five months and less than full capacity for seven to nine months. An alternative to this structure could be to have all processing sites/plants processing milk in the peak months of April to July, and as the milk supplies reduce, close processing sites/plants and divert the milk into fewer sites/plants. The seasonalised processing site would incur the additional cost of transporting milk to alternative sites, but would gain from the substantially reduced processing costs as well as a more diversified product portfolio. The processing sites that remain open would gain from being less seasonal, achieving economies of scale from processing greater volumes of milk and, therefore, reducing their processing costs.

Greenfield processing site

An alternative option would be to construct a greenfield processing facility which would be strategically located in relation to the number of milk producers and is ideally located for distribution in order to keep transport costs down. This site would (a) have the capacity to process a large proportion of the expected increased milk production at peak with the phasing out of milk quotas; (b) be flexible to enable other plants to shut down when the milk supply is low; and, (c) allow the industry to respond to market demand with regard to the products being produced.

Milk pricing systems

Multiple component pricing systems

The Irish dairy industry is currently in the process of implementing the A+B-C system of milk payment (where price is for fat plus protein content less a constant for milk yield). A clear, transparent payment system based on milk composition for the producer is essential. This system allows processors to send signals to the producers quickly in relation to market movements, therefore ensuring market reactivity and thus efficiency of the dairy industry.

Seasonal milk payment system

Similar to the A+B-C system of milk payment, the optimum milk supply profile should also be rewarded. This should be used as an incentive to farmers to produce high quality milk under the most profitable supply profile for the Irish dairy industry. Minor adjustments to the peak-to-trough ratio and capacity utilisation would have substantial effects in the requirement for additional processing facilities with expansion and, therefore, on the price of milk.

Mechanisms to reduce price volatility

In the past year alone the dairy industry has seen the price per litre of milk fluctuate from a high of 37.7c/l to a low of 20c/. Volatility in price will result in only the lowest cost producers remaining in milk production. This highlights a requirement to develop effective sales structures that limit the impact of fluctuating milk prices on producers and processors. Price risk management and futures markets, as have been implemented in the USA and New Zealand, are strategies that could be beneficial for Ireland.

Carbon mitigation strategies

Combating climate change through the reduction of carbon emissions is a high priority for EU government, having committed to reducing Ireland's greenhouse gas emissions by 20% by 2020. Strategies to mitigate the carbon emissions at farm and processor level will need to be examined. There are substantial reductions in emissions that are possible at farm level through focusing on grass-based technologies with high EBI genetics. The first and most important step in relation to carbon in the processing sector is to ascertain the current processing sector emissions.

Dairy industry model

A project being undertaken by Teagasc Moorepark, in partnership with the Rural Economy Research Centre, University College Cork, University College Dublin and Cork Institute of Technology, seeks to determine the best strategies that will position the dairy industry to overcome the challenges outlined above. This is a Research Stimulus Fund project funded by the Department of Agriculture, Fisheries and Food under the National Development Plan 2007-2013. Consultation will be carried out with processors, the Irish Co-operative Organisation Society, the Department of Agriculture, Fisheries and Food, the Irish Dairy Board and farmer representatives to ensure a complete industry perspective. A core component of this study will be the completion of a comprehensive survey of the milk processing sector, which will inform the development of an industry model.

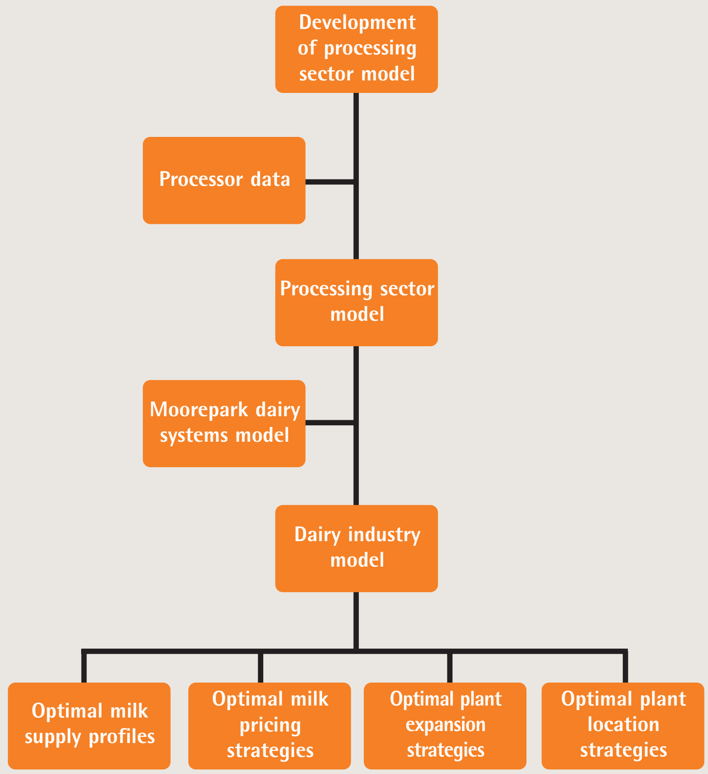

FIGURE 2: Flow diagram of project.

The models will facilitate:

- determination of the optimum model for milk processing in Ireland;
- development of strategies to maximise product portfolio, minimise processing costs thereby maximising the profitability of the dairy industry;
- development of the most efficient milk supply profile for the dairy industry;
- development of milk pricing systems to maximise the industry profitability;
- development of the optimum expansion strategies within the dairy processing sector; and,
- determine the carbon number of dairy products and the development of mitigation strategies for both the processing and farm sector.

This Moorepark-led Research Stimulus Fund project will support the formulation of strategies for policy makers, milk processors and farm organisations in an era of substantial policy and market change, with the aim of securing the future viability of the farming sector.

Una Geary, Research Officer and **Laurence Shalloo**, Senior Research Officer, Moorepark Dairy Production Research Centre. **Thia Hennessy**, Rural Economy Research Centre, Athenry. E-mail: una.geary@teagasc.ie.



Technology adoption and innovation

Adoption of new technology and innovation in dairy farming forms the basis of planned expansion in the dairy industry. MATT RYAN, GEORGE RAMSBOTTOM and KEVIN HEANUE explain the activities in place to assist farmers to deal with these issues.

The expected abolition of milk quota in 2015 will result in Irish dairy farmers facing a less regulated global trading environment with more volatile prices than previously. In such an environment, dairy farmers will need to expand by increasing scale, producing premium product and controlling costs. The adoption of key technologies will be essential to help meet these challenges. This article identifies the key technologies – animal breeding, grassland management, financial management and labour efficiency – that need to be efficiently adopted. In addition, the article shows that although the biosciences are critical for the development of such key technologies, the social sciences also have a role to play in helping understand why technologies may or may not be adopted, and therefore, why cost and profitability variations persist.

Integration of key stakeholders

The close integration of dairy advisory and research plus a strong commodity group (which acts in an advisory capacity and provides feedback on the programme) are essential in technology innovation and adoption. Four critical steps are involved in the smooth functioning of Teagasc's dairy research and advisory programme.

1. The Dairy Commodity Team, comprised of farmers and industry personnel, ensures that the technologies being researched and subsequently promoted are of relevance to Irish dairy farmers.
2. A team of dairy researchers based at Teagasc Moorepark who carry out research in the areas identified as priorities by the Commodity Team.
3. A dedicated team of dairy specialists who closely liaise with their research colleagues and quickly transfer the research messages to advisors.
4. Teagasc's Advisory Service – currently 75 Business and Technology (B&T) dairy advisors are specifically involved in the transfer of research to dairy farmers.

This structure has facilitated the move away from the 'top-down' to 'bottom-up' flow of information. The Commodity Team meets approximately three times per year to guide the dairy research and advisory programmes. Their contributions help to ensure that the research and advisory programmes conducted by Teagasc are relevant to dairy farmers and the wider industry. In addition to the Dairy Commodity Team, a Joint Programme Development Team composed of Teagasc dairy research and advisory personnel was established. The purpose of this team is to agree the direction of the research and advisory programmes as developed in consultation with the Commodity Team. It aims to establish a closer relationship between research and advisory so as to advance innovation and technology adoption more rapidly. This process is outlined in **Figure 1**.

Business planning

The data in **Table 1** highlights the potential that exists for individual spring milk producers to address the income challenge – particularly so for those in the 'average' and 'bottom 10%' categories (based on profit monitor results for 1,030 spring milk producers in 2008).

Table 1: Preliminary analysis of the costs and profitability of spring milk producers (2008) by milk solids (ms).

	Average	Top 10%	Bottom 10%
Total costs in €/kg ms	2.92	2.28	3.98
Net margin in €/kg ms	1.94	3.07	0.56
Net margin/ha	€1,439	€2,476	€345

In assisting farmers to address those challenges, the Teagasc Advisory service has developed a Dairy Business Plan. The main objective of this plan is focused on improving dairy farmers' income. To achieve this objective the plan has identified specific technologies and target levels of efficiency which must be achieved by dairy farmers. The specific overall financial objective is that dairy farmers will achieve a net profit of €2,500 per hectare while producing milk at production costs of less than €2 per kilogramme of milk solids. Crucial to achieving this is the adoption of key technologies in animal breeding, grassland management, financial management and labour efficiency. The 'top 10%' category outlined in **Table 1** contains farmers who have already adopted some or all of these essential technologies.

Relevant technologies

All businesses must continually innovate and adopt new technologies. This equally applies to farmers engaged in the Irish dairy industry. However, to ensure wide adoption, such technologies must be:

- of relevance to the target audience, i.e., the dairy farming community; and,
- promptly and effectively promoted.

Research carried out in New Zealand has shown that technologies are more likely to be adopted by dairy farmers if they have clearly identifiable benefits, are cheap or affordable, save time and are simple to adopt. Economic models may fail to recognise that the decision-making of farmers is driven by many psychological and sociological factors. Personal, family and farm business objectives are inter-dependent and they need to be considered together. Social science research at the Rural Economy Research Centre will help to improve understanding of such technology adoption and diffusion issues. Social science analysis can help identify the characteristics of farmers who either do or do not adopt particular technologies.

There is a need to analyse the attitudes, motivations and learning processes of farmers in the context of adoption. This approach is increasingly being followed internationally. The attitudes and motives of potential adopters, in addition to economic drivers, emerge as key factors to be understood in the adoption/non-adoption decision. In terms of learning, it is accepted that there are a variety of ways in which new knowledge is learned. An appreciation of these learning processes, therefore, is crucial for understanding technology adoption processes. Attitudinal, motivational and learning factors are also likely to be related in some way to whether the technology is management-intensive as opposed to capital-intensive. Management-intensive technologies may appear more complex and less applicable to the farmer (and therefore are not adopted as quickly or easily) in contrast to a capital-intensive technology whose effective use is more self-evident. Understanding such issues is important, as there is international evidence that the adoption of such technologies among dairy farmers lowers the likelihood of a farmer being in the lowest quartile of production performance.

Research to extension

Research is the key to innovation which ultimately carries the label 'this practice should be adopted by dairy farmers'. Effective promotion and marketing are key elements in the successful adoption of technology by farmers. It is not sufficient that the relevant research is conducted and that the technologies are developed. Promotion through the Teagasc Advisory Service is critical in ensuring that adoption takes place. The role of the 75 B&T dairy advisors is primarily to ensure that the latest technologies are transferred to commercially viable full-time dairy farmers. To ensure that effective technology transfer occurs, such advisors must have a good understanding of the latest findings from research. This happens in two ways:

1. B&T dairy advisors are regularly updated at in-service training by dairy researchers; and,
2. Dairy specialists who, in close liaison with researchers, ensure that research messages are communicated effectively to B&T Dairy Advisors through:
   a) regular in-service training;
   b) adaptation of research results for the target audience – dairy farmers;
   c) computer programmes, worksheets and checklists to assist in promoting the key technologies to their clients;
   d) facilitation and communication training; and,
   e) individual support of advisors.

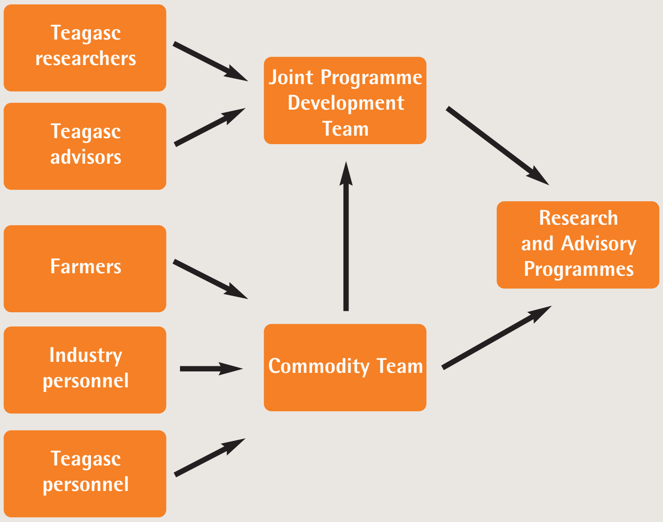

FIGURE 1: Composition of teams steering the Teagasc dairy research and advisory programmes.

Extension to dairy farmer

A wide range of extension methodologies are employed to transfer research to dairy farmers. Researchers conduct a limited amount of extension through joint initiatives with their advisory colleagues. Dairy specialists principally extend research through mass extension methodologies including seminars, walks and publications. B&T advisors extend research through farm visits, farm walks and discussion groups. The B&T dairy advisor is the extension agent with the responsibility for transferring research technology to dairy farmers. Social science researchers can play a role in extension by working with advisors and farmers in order to better understand the learning processes that occur during different types of extension activities. This knowledge should then be used as a resource for the design and implementation of extension activities.

Farm visits/office consultations: each of Teagasc's 75 B&T dairy advisors has an average of 120-150 contracted clients entitled to one-to-two farm visits per year. Research shows that such individual contact is a very effective means of ensuring that technology adoption takes place.

Discussion groups: B&T dairy advisors facilitate 250 dairy discussion groups. Each group has an average of 12-15 dairy farmer members and meets 8-10 times per year.

Farm walks: Each B&T advisor provides their clients and non-clients (through publicly advertised events) with the opportunity of seeing research in operation in their own locality. An average of two-to-three such walks are organised annually in each advisor's area. They generally take place on Monitor Farms, TET or BETTER farms with back up from researchers and dairy specialists.

Seminars/meetings: These take place at county/local venues either in spring or autumn to complement two national dairy conferences held in November. The focus of these seminars is normally closely aligned to the aims of the dairy development programme.

Others: The principal short courses conducted by B&T dairy advisors were:

- computer courses;
- financial courses; and,
- breeding and grass budgeting courses.

Teagasc dairy clients receive a dairy newsletter each month containing timely technical information and research updates. Teagasc has a number of joint programmes with the major dairy co-operatives. These programmes are generally focused on achieving specific objectives of interest both to Teagasc and its co-operative partner.

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Tomorrow's milkers: sourcing and training

PADDY BROWNE, Assistant Director, Teagasc Knowledge Transfer and Education Directorate, outlines the future training needs for the dairy industry and how these can be met.

Introduction

Meeting the future labour requirements on Irish dairy farms will require a supply of young highly educated farmers and skilled operatives. The farmer/managers will come from the ranks of young entrants to full-time training, but a number of part-time farmers will also need to be convinced of a future in dairying and make the transition to full-time farming. Family-based farms will continue to be the backbone of the sector but will only survive if services and practices are utilised to ensure a reasonable quality lifestyle. Large-scale operations will depend on a supply of skilled labour, including migrant workers, and a co-ordinated approach is required to improve the skill levels and retention of these workers.

Present situation

The total number of students enrolling in Teagasc agriculture colleges in 2008 was 1,049, which represents a 36% increase over 2007. A 25% increase in enrolments was seen in 2007 over 2006. This represents a reverse of recent trends, with enrolments back to the numbers that were seen in the early 1990s. There are a number of reasons for the increase in college enrolments in the last two years:

- the downturn in the construction industry, with a corresponding reduction in the numbers entering trade apprenticeships and going straight into employment;
- the prospect of a freeing up of the milk quota regime; and,
- the increased difficulty of the alternative route, i.e., the Advanced Certificate in Agriculture, combined with a Level 6 non-agricultural qualification, replaced the former 180-hour course.

A noticeable feature in recent years is the decrease in the numbers of sons and daughters of farmers with sizeable farms who are attending colleges. Many serious farmers, along with career guidance teachers, are discouraging their sons and daughters from planning a full-time career in farming and encouraging them to pursue a non-agricultural qualification. Of those who do attend, there is an increasing tendency to follow a higher level course or transfer to a higher level course after first year or second year; their motivation is to progress to degree level and to combine a career as a professional in the agriculture area with part-time farming.

The decline in numbers pursuing full-time further level courses in college has been counterbalanced in recent years by an increase in the numbers of part-time farmers attending the part-time option at local level. So, while the overall numbers attending agriculture training programmes has remained relatively stable, there has been a significant shift towards the part-time route, with at least 80% of participants apparently planning to be part-time farmers.

Advanced training in dairy farm management

Another very noticeable trend has been the decline in the numbers participating in the Advanced Certificate in Farm Management (formerly the Farm Apprenticeship Scheme) (**Table 1**). This programme, which incorporates three years' placement on a master farm, has proven to be an excellent preparation for future farmers and farm managers, and some of Ireland's leading farmers are graduates of the programme.

TABLE 1: Participation rates in the Advanced Certificate in Farm Management.

Year	First year recruits	Total participants
1986	166	371
1990	92	281
1996	93	247
2002	22	87
2005	4	25
2006	0	15

This decline has taken place in spite of very intensive recruitment by the Farm Apprenticeship Board up until 2002, and subsequently by Teagasc. On a more encouraging note, there is a significant increase this year in the numbers enrolling on the Advanced Certificate in Dairy Herd Management (33).

Future labour needs

It is projected that the dairy industry of the future will comprise a total of 12,000 farmers but with two distinct profiles of dairy farmer. The majority of farmers will be in the 80- to 120-cow category and will build their business on the basis of one-person operations. Their buildings and operation will be streamlined so as to minimise labour requirements and they will be looking towards farm practices and services that will give them a reasonable quality lifestyle while keeping costs to a minimum.

The second category of farmers, while small in numbers, will be significant in terms of output, and will comprise large scale 300- to 500-cow operations. These operations will include the owner/manager and will depend on a number of hired-in labour units.

Meeting the labour needs of the future

One-person operations

As was shown earlier, there is no shortage of people entering agricultural training but the vast majority are entering with a view towards farming on a part-time basis. A significant proportion of the dairy farmers of the future will come from the ranks of the full-time students, but we will also need a proportion of the part-timers to become full-time farmers. This is often the intention because most farms cannot support two families with the inheritors waiting until the retirement of their parents. However, this transition will only happen if these part-timers can see a viable future in full-time dairy farming.

These one-person operations will then need to adopt practices and avail of services that will give them a reasonable quality lifestyle.

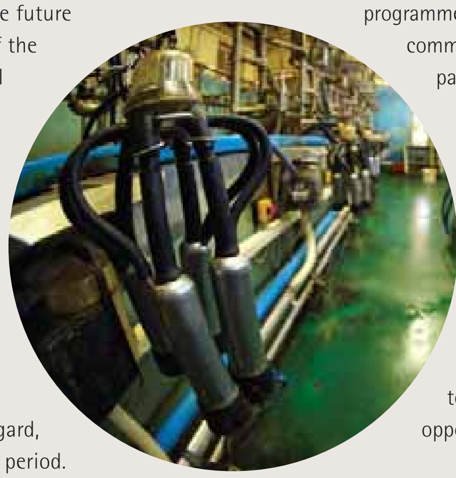
The Farm Relief Services will continue to play a vital role in this regard, as will students on three-month placement during the busy spring period. Other mechanisms of interest include once-a-day milking, farm partnerships and shared labour/machinery arrangements.

The ideal preparation for these intensive dairy farmers of the future is the Advanced Certificate in Dairy Herd Management. This course is currently offered at Kildalton, Clonakilty and Ballyhaise and is open to students who have completed the one-year FETAC Level 5 Certificate in Agriculture. Students spend 20 weeks at the college specialising in the most modern aspects of dairy management, and this is followed by 12 weeks' placement on intensive dairy farms. Many students complete this placement overseas in places such as New Zealand and the USA.

Large-scale operations

The development of large-scale dairy operations will depend on a supply of highly educated owner/managers, as well as a supply of reliable hired labour. During the Celtic Tiger, dairy farmers became increasingly reliant on migrant workers and, while there is now an increased availability of Irish workers, migrant workers will continue to play an important role in this area. Teagasc is involved in a number of training initiatives aimed at improving skill levels and retention of farm operatives, including migrant workers. We have already been involved in developments in the horticultural sector and short training modules at Kildalton College for operatives on dairy and pig farms. These one-week modules are aimed at providing the relevant farming skills, combined with language and life skills.

The owner/managers of large-scale dairy farms will need intensive grounding in both technology and business skills. At a minimum, they will need the Advanced Certificate in Dairy Herd Management outlined above, but should strongly consider the new Bachelor of Agricultural Science – Dairy Business programme at UCD. This four-year programme, which commences in September 2009, will provide participants with a high level of scientific, technical and business skills. The scientific and business skills will be provided during years 1, 2 and 4 at UCD, including time at the renowned Quinn Business School. Year 3 will comprise advanced skills training at Kildalton prior to a six-month placement (hopefully in New Zealand). The second semester in year 3 will be spent at Teagasc Moorepark, where participants will be exposed to the latest dairy research and will have the opportunity to liaise with researchers at the centre.



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Farm restructuring systems provide the key

Farm restructuring systems are required to facilitate dairy expansion, explain BEN ROCHE, THIA HENNESSY, ANNE KINSELLA and FIONA THORNE.

Farmers are facing a future of lower prices for their produce and higher operating costs. Dairy farming viability will be dependent on farmers being able to increase the scale of their operations. The feasibility of expansion of a dairy herd on a grass-based system of farming, as operated in Ireland, is dependent on being able to acquire extra resources at an affordable level.
Like most countries in Western Europe, the average farm size in Ireland is small relative to that of our competitors in such places as New Zealand, Australia, South America, the USA and Canada. The full benefits of advances in mechanisation and technology can only be reaped by increasing farm size. Land prices are high in Ireland and increases in farm size through acquisitions have been limited. Driven by the farmer Early Retirement Scheme and generous tax incentives, leasing has become more popular; however, the amount of leasing to non-family members is limited in extent. Short-term rental is still popular but of limited value to dairy farmers who require land with medium-term or long-term security of tenure.
Collaboration between farmers is another possible solution. This article examines collaboration between farmers as a way of achieving economies of scale.

Economic rationale for collaboration

Recent research conducted in the Rural Economy Research Centre, Teagasc, and the Department of Economics in TCD, examined the relationship between technical efficiency and scale of operation on Irish farms. The importance of the scale of operations was of particular interest. The analysis showed that increasing returns to scale are present on Irish dairy farms. The results highlight that larger farms are more efficient. This implies that increasing scale is likely to lead to increases in productivity. This finding presents a serious challenge for policy makers and for those involved in planning the future of Irish agriculture, which at present is characterised by relatively small-scale operations (internationally). The implications of our scale of operations for our intentional competitiveness are highlighted in a separate paper in this edition of *TResearch*.

Examples of collaborative arrangements in farming internationally

In other countries, various collaborative arrangements have been tried, some with great success, as follows:

(a) GAECs

This refers to a farm partnership system in France called *Groupements Agricoles d'Exploitation en Commun* (GAEC), or joint farming agricultural groupings. A GAEC consists of two or more farmers who pool their land, labour and other farming resources. They then operate the farm business under an agreed plan and are required to meet registration requirements. GAECs are unique in the EU in that they are the only fully recognised collaboration system where all the qualifying farmers in the group are treated as favourably as farmers farming on their own with regard to EU and Government supports. Farmers in Milk Production Partnerships in Ireland have been given only some of these individual benefits.

(b) Share milking

Over the years share milking in New Zealand has provided a pathway to facilitate older farmers to retire and the entry of young aspiring dairy farmers. Currently, Teagasc, in association with a consultative committee, is in the process of developing a share farming model to suit Irish conditions. Initially, this is focusing on the tillage sector.

(c) Equity partnerships

Another New Zealand development is that of equity partnerships. These are legally constituted as companies. All assets, such as land, buildings, livestock and machinery are acquired by the company. Such entities are usually composed of anything from two to 10 shareholders. Normally, only one of the partners is an active partner known as the manager.

Milk production partnerships

In Ireland, the Milk Production Partnership (MPP) Scheme was established as a way of achieving scale by facilitating farmers to manage their farms in partnership. This scheme was broadly modelled on the French GAEC system. Entering a partnership offers farmers a number of benefits, such as the ability to achieve scale at a lower capital cost, the reduction of costs that are duplicated between farmers, management synergy and risk sharing. In a country such as Ireland, where the availability of land for purchase is both minimal and expensive, partnership arrangements offer farmers the ability to achieve scale without incurring major capital debt. Coming together in a partnership facilitates the disposal of costs that are duplicated. Farmers can share machinery, buildings and labour. Potential benefits from machinery sharing arrangements between farmers include reduced capital costs and the possibility of investing in more advanced technology. The sharing of labour can support task specialisation among the partners, thus increasing the overall efficiency of the farms. Labour sharing can also lead to better time management and a greater work–life balance for the partners involved. Collaboration and partnership among farms can lead to management synergy, especially if it is collaboration between farmers coming from two different enterprise backgrounds, beef and dairy for example. If farmers differ in managerial ability, those with relatively low managerial ability will benefit from the experience of working with those with relatively high managerial ability.

Policy mechanisms required to ensure that farm partnership arrangements are allowed to operate without disadvantage

The MPP Scheme commenced on a pilot basis in a very restrictive way in 2002. Initially, it was only open to dairy farmers and the partnership was treated as if it were a single farmer for all EU support schemes except for the milk quota regulations. Such restrictions have impeded its uptake. Some restrictions, such as age limits and opening participation to non-dairy farmers, have recently been lifted. The following special provisions have been introduced:

REPS 4

Following a submission to the EU Commission, special provision was introduced to facilitate MPPs under REPS 4 so as to ensure that payments are made on the basis of the number of qualifying partners involved. This was a very important development.

Finance acts

Provision was introduced in the 2006 Finance Act to provide for spouses who are co-owners of land farmed in MPPs in which they themselves are not farming partners. The provision is to preserve entitlements to Capital Gains Tax retirement relief. A second provision was introduced in the 2008 Finance Act to provide for farmers who are on income averaging and subsequently enter into an MPP. The provision prevents possible clawback of income tax saved because of averaging.

More policy changes required

Exemption from modulation deductions on the first €5,000 of Single Farm Payments

Modulation deductions are currently applied at 7% of Single Farm Payments with an exemption on the first €5,000 on each payment. This modulation deduction will increase to 10% by 2012. Currently, MPPs are given only one €5,000 exemption rather than one for each farmer involved. The loss in Single Farm Payment to a partnership involving three farmers this year will be €5,000 x 7% x 2 = €700. This will increase as the percentage deduction increases over the next few years.

Disadvantaged Areas Compensatory Allowances Scheme

In this case the limit applied is one of area, in that the maximum area in respect of which payments can be made is 34 hectares. The limit applies whether the recipient is an individual farmer with one holding, or an MPP with two or more farmers and holdings. A strong argument can again be made for a lifting of the ceiling in the case of MPPs in accordance with the number of partners involved, i.e., 68 or 102 hectares in the case of two or three partners.

'Capping' of payments

An important issue is that special provision would need to be made for the fact that Single Farm Payments being made to MPPs are higher than that which would be paid to the individuals concerned. If capping of payments is applied at a future date, the capping should apply at the level of the individual, and not of the MPP.

Other EU/Government support schemes

Other financial support schemes, such as the Early Retirement Scheme, On-Farm Investment Schemes and Installation Aid, which are currently suspended or have run their term, were all operated on the basis of treating MPPs as if they were single farms. This proved to be a considerable disincentive to participants in MPPs.
Any future supports to farmers participating in recognised structures, such as MPPs, should be on the basis of giving full individual recognition to all qualifying participants on the same basis as if they were farming on their own.

Incentives for young farmers and managers

Dairy farming by its nature is essentially a young person's business. Therefore, it is imperative that young people, whether as aspiring future inheritors or farm managers, are not just educated and trained in the business of dairying, but are also motivated by means of operating structures, supports and incentives to progress in their career.

Conclusions

This article has highlighted the serious challenge that exists for policy makers and for those involved in planning the future of Irish agriculture, which at present is characterised by relatively small-scale operations (internationally). The article has highlighted various policy measures that are necessary to facilitate the uptake of partnerships in Irish dairy production. The need for Irish diary farms to examine restructuring options to facilitate dairy expansion has been highlighted. Recent research conducted by Teagasc, in collaboration with TCD, has highlighted the importance of economies of scale found in ensuring our competitive advantage in diary production in the future.

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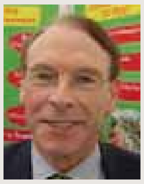


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- Economics and Rural Development

Knowledge Transfer and Education

Ensures that new and available knowledge is efficiently transferred for the benefit of stakeholders through:

- Developing new strategies and integrated programmes to support stakeholder innovation
- Providing education programmes for new farm entrants, agri-food SMEs, and life-long learning for both farmers and rural dwellers to underpin the application of knowledge

Advisory

Our advisory programmes provide support for farmers and rural dwellers in responding to a fast-changing world through knowledge initiatives in:

- Business and Technology
- Environment and Technology
- Rural Development

NDP
National Development Plan 2007 - 2013
Transforming Ireland

Teagasc 2030

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