

Research

Volume 12: Number 3. Autumn 2017

Waste2Fuels

CREATING NEXT GENERATION BIOFUELS

ICOMST 2017

PROWELCOW

PROTEINS OF THE FUTURE

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EDITOR

Catriona Boyle 076 111 1219
catriona.boyle@teagasc.ie

ADMINISTRATOR

Ann Tiernan
ann.tiernan@teagasc.ie

EDITORIAL STEERING GROUP

Catriona Boyle	Stephen Butler	Michael Diskin
Eric Donald	Niall Farrelly	Helen Grogan
Tim Guinee	Richard Hackett	Ann-Marie Hardiman
Anne Kinsella	Gary Lanigan	Sinéad McCarthy
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TResearch Teagasc,
Oak Park, Carlow, R93 XE12

Published on behalf of Teagasc by

Th!nkMedia

The Malthouse, 537 NCR,
Dublin 1, D01 V822.

T: 01 856 1166 E: ann-marie@thinkmedia.ie www.thinkmedia.ie

Design: Tony Byrne, Tom Cullen and Eimear Moroney

Editorial: Ann-Marie Hardiman, Paul O'Grady and Colm Quinn

Encouraging diversity in research

How often do you consider diversity within your organisation or project teams? Diversity matters. In an era of uncertainty, constant change and the need for innovative solutions to address national and global challenges, the case for greater diversity becomes more compelling. Research has shown that organisations with more diverse workforces perform better. The same is true for teams. Diverse teams are smarter. Why? Because people with different backgrounds alter the group's behaviour leading to better thinking. Diverse teams are more likely to remain objective and they are more innovative. Ethnicity, gender, expertise, education, age and manner of thinking are just some dimensions of diversity.

The dimension receiving much media attention recently, and which will impact the research community, is gender equality. From 2019, Ireland's three main research funding agencies (Science Foundation Ireland, the Health Research Board and the Irish Research Council) will require higher education institutes to have gender equality accreditation in order to be eligible to compete for research funding. Gender equality is a key element of successful research and innovation, and this move aims to promote gender equality in research careers and in research content. While Teagasc is not a higher education institute, it is a research institute that competes for funding from these sources and we expect the same criteria will apply in the future. Actions are underway to develop a gender equality plan within Teagasc.

Women are still under-represented in science and a lack of female role models is cited as a key reason. Female role models are important for promoting gender equality among researchers and also as a source of inspiration for young girls and women interested in pursuing careers in science. To coincide with Science Week (November 12-19) we are compiling a publication profiling Teagasc's women in agri-food research, highlighting their diverse backgrounds and the variety of areas where they are contributing valuable knowledge to the agri-food industry.

We hope this publication will be a source of inspiration for young females interested in science, providing role models they can relate to while increasing their awareness of career opportunities in agri-food research. In addition, we hope that this publication will be a source of potential collaborators for future research projects.

We need to embrace and enhance diversity in our research teams to develop innovative solutions to complex problems.



Jane Kavanagh

Head of Research Operations

Éagsúlacht a spreagadh i dtaighde

Cé chomh minic is a bhreithníonn tú cúrsaí éagsúlachta laistigh de d'eagraíocht nó laistigh de d'fhoirne tionscadail? Is tábhachtach atá éagsúlacht. Is láidre fós an argóint ar son éagsúlacht mar gheall ar ré na héiginnteachta, ar sinn a bheith faoi réir athrú leanúnach agus ar an ngá atá le réitigh nuálacha chun aghaidh a thabhairt ar dhúshláin náisiúnta agus dhomhanda. Léirítear go bhfuil an fheidhmíocht is fearr le brath i measc eagraíochtaí agus foirne ag a bhfuil fórsa saothair éagsúil. Tá foirne éagsúla níos cliste ná foirne eile. Cén fáth? Toisc go ndéanann daoine ag a bhfuil cúlraí difriúla athrú ar iompraíocht an ghrúpa. Tá seans níos fearr ann go mbeidh foirne éagsúla oibiachtúil. Tá siad níos nuálaí ná foirne eile. I measc na ngnéithe d'éagsúlacht tá eitneacht, inscne, saineolas, oideachas, aois agus modh smaointeoireachta.

Is é comhionannas inscne an ghné is mó plé sna meáin le déanaí agus rachaidh sé i bhfeidhm ar an lucht taighde. Ón mbliain 2019 i leith, ceanglóidh Fondúireacht Eolaíochta Éireann, an Bord Taighde Sláinte agus an Chomhairle um Thaighde in Éirinn ar institiúidí ardoideachais creidiúnú comhionannais inscne a bheith acu ionas go mbeidh siad incháilithe do dhul san iomaíocht le haghaidh cistiú taighde. Tá comhionannas inscne ina ghné thábhachtach de thaighde agus de nuálaíocht rathúil, agus is é an aidhm atá leis an gcreidiúnú sin comhionannas inscne a chur chun cinn i ngairmeacha taighde.

Is institiúid taighde é Teagasc a théann san iomaíocht le haghaidh cistiúcháin. Táimid ag súil leis go mbeidh na critéir chéanna infheidhme inár leith sa todhchaí. Dá bhrí sin, tá gníomhartha ar bun chun plean comhionannais inscne a fhorbairt laistigh de Teagasc. Tá tearcionadaíocht á déanamh do mhná san eolaíocht agus meastar go bhfuil an easpa eiseamláirí do mhná ar cheann de na príomhchúiseanna leis sin.

Tá eiseamláirí den sórt sin tábhachtach maidir le comhionannas inscne a chur chun cinn i measc taighdeoirí. Tá siad ina bhfoinse inspioráide do mhná a bhfuil spéis acu i ngairm a shaothrú san eolaíocht. Ar mhaithe le Seachtain na hEolaíochta a chomóradh (12-19 Samhain), tá muid ag cur foilseachán le chéile, áit ina bhféachtar ar na mná de chuid Teagasc atá ag gabháil do thaighde agraibhia agus ina dtarraingítear aird ar chúilraí éagsúla na mban sin agus ar na réimsí difriúla ina mbíonn siad ag cur eolas luachmhar ar fáil. Tá súil againn go mbeidh an foilseachán ina fhoinse inspioráide do mhná óga a bhfuil spéis acu san eolaíocht. Tá súil againn freisin gur tríd an bhfoilseachán a mheallfar daoine chun comhoibriú linn ar thionscadail taighde amach anseo. Má táimid chun teacht ar réitigh nuálacha ar fhadhbanna casta, is gá dúinn éagsúlacht a chur chun cinn agus a mhéadú inár bhfoirne taighde.

Jane Kavanagh

Ceann Oibríochtaí Taighde

Teagasc Fulbright Award winners



Well done to the 38 Fulbright Irish awardees who were announced in June by then Minister for Foreign Affairs and Trade Charlie Flanagan, and Mr Reece Smyth, Chargé d'affaires of the US Embassy in Ireland. These awardees will go to top US institutions to study and collaborate with experts in their field.

Jaswinder Kaur, a PhD candidate at Limerick Institute of Technology, is the Fulbright-Teagasc awardee. She will be based at Michigan State University, investigating the use of genome

sequences of fungi and identifying crucial genes responsible for the production of putative enzymes for industrial applications. Laura Devaney, a postdoctoral researcher at Teagasc, examining development pathways for the Irish and European bioeconomy, received the Fulbright-EPA scholarship to research the development and governance of the US bioeconomy.

The 2018-2019 awards are now open for applications: www.fulbright.ie.

Inspirefest

Alberto Corrochano, Food Chemistry and Technology Department, and Bhagya Jonnala, Food Bioscience Department, Teagasc Food Research Centre, Moorepark, were among eight students nationally to be selected as finalists to speak at Researchfest 2017 (part of Inspirefest). Inspirefest is a unique international festival of technology, science, design and the arts.





Food Works programme:

Irish accelerator programme for food and drink start-ups. Run by Bord Bia, Enterprise Ireland and Teagasc since 2012.



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How farmers can help bees

Pictured at the launch of a new leaflet 'How Farmers can help Bees' at the Teagasc National Crops and Cultivation Open Day in Oak Park were (from left): Mary Coffey, University of Limerick/Teagasc; Gerry Ryan, President of the Federation of Irish Beekeepers' Associations; Gerry Boyle, Teagasc Director; and, Catherine Keena, Teagasc Countryside Management Specialist.



'Bees need wildflowers on farms' was the message from Teagasc and the Federation of Irish Beekeepers' Associations (FIBKA) at the Teagasc National Crops and Cultivation Open Day in Oak Park in June, where a new leaflet 'How Farmers can help Bees' was launched. Addressing tillage farmers at the open day, Catherine Keena, Teagasc Countryside Management Specialist, said: "Pollinators, especially bees, are important, but unfortunately are in decline. We need more

wildflowers in the countryside. Bees need food all year round, requiring a diversity of flowering plants in the landscape. Farmers can help bees by allowing space for wildflowers to grow and flower within hedgerows and field margins, around farmyards, along farm roadways and in field corners. The quest for neatness on farms should not override consideration for bees". A playlist of videos from the event can be viewed on Teagasc's YouTube page.

Festival of Farming and Food

Teagasc is delighted to receive funding from Science Foundation Ireland for the 'Festival of Farming and Food', which runs during Science Week 2017 (November 12-19) with events for schools and the general public. For full details of events see: www.scienceweek.ie.



Sheep open day



The sheep open day at Teagasc Athenry in June focused on grass-based systems of lamb production, breeding – incorporating the indices, economic evaluations, genomic selection, and looking at low- and high-index rams – flock health and hill sheep production. A playlist of videos from the event can be viewed on Teagasc's YouTube page.

Situation and Outlook

Teagasc has published its mid-year commentary on the economic performance of Irish agriculture in 2017.

It forecasts very strong growth in dairy incomes, with broadly stable incomes elsewhere.

Milk prices have rebounded strongly over the last 12 months.

They are now back to 33c/L and are providing the impetus for a continuing increase in milk production. Average dairy farm margins could double in 2017.

In spite of the weakness of sterling, which has an impact on beef returns from the UK, strong demand elsewhere should lead to a small increase in beef prices. Margins on single suckling farms will be largely stable, while margins on cattle finishing farms will be 11% higher than in 2016.

Sheep farm incomes should increase due to improved farm productivity boosting both the volume and value of output, and leading to a small increase of 4% in gross margin per hectare. On the tillage side, unfavourably dry conditions in April will likely lead to lower yields; however, fertiliser prices have been lower and it looks like cereals prices will be higher this year. Tillage incomes should be higher in 2017 due to decreased production costs.

The Teagasc Situation and Outlook July 2017 document is available at: <https://www.teagasc.ie/media/website/publications/2017/Situation-and-Outlook-July-2017.pdf>.

Researcher profile

Dermot Forristal is a Principal Research Officer working in the Crop Science



Department in Teagasc Crops, Environment and Land Use Programme, Oak Park, Carlow. Dermot joined the then Agricultural Engineering Department at Oak Park in 1983 and since then has focused primarily on mechanisation aspects of the research programme. Silage mechanisation was a key research area and Dermot was involved with wrapped baled silage from its inception. Much of the work that

he carried out, in collaboration with Padraig O'Kiely of Grange, provided the technical knowledge that allowed this flexible and adaptable system to be effectively deployed on Irish livestock farms. The impact of machinery on the soil, of particular interest in our climate, has been and continues to be a focus of Dermot's research. Machine trafficability during forage harvesting was an early research objective, from which the adoption of larger tyres and lower ground pressure systems on vulnerable soils became more common, resulting in more timely harvesting, and reduced soil and sward damage. Dermot still works on compaction-related areas, with involvement in two current RSF-

funded collaborative projects (SQUARE and CTF Optimove) examining soil structural quality and studying the impact of arable crop headlands on soil structure and crop performance. This interest in the machine/soil interface also underpins Dermot's research in soil cultivation and crop establishment systems. In this area, the impact of cultivation systems, such as minimum tillage or strip tillage, on crop response, but also on the soil, the environment and production costs, is assessed. This is challenging, longer-term work as the evolved cultivation systems from other climates may not prove sustainable in our climate. Crop rotation and break crops also form part of his research

Dermot Forristal

portfolio, along with precision agriculture.

Dermot has always had an applied approach to his research and dissemination and, in addition to the topics mentioned, he has worked on machinery costs and selection, and provides expert knowledge in the areas of fertiliser spreading and spraying. Dermot is currently involved in supervising five PhD students across a range of projects. He has also participated in the running of an ERAnet and is involved with industry through the stakeholder group. He was part of the team that produced the tillage sector development plan. Dermot lives on a farm in Co. Kilkenny and helps out in a local canoe club in his spare time.

Moorepark 2017

The expansion in the Irish dairy industry over the last three years has been of significant financial benefit to both Irish family farms and the wider rural economy.

That was the message from Director of Teagasc, Gerry Boyle, speaking at the Teagasc Moorepark dairy open day in Fermoy, Co. Cork, in July. Further expansion will depend on the adoption of 'Resilient Technologies', which was the theme for the open day. The day was sponsored by FBD Insurance and attracted thousands of farmers from all over the country and abroad. A playlist of videos from the event can be viewed on Teagasc's YouTube page.

Teagasc researcher Donagh Berry talks about 'The Perfect Cow' at the Moorepark 2017 dairy open day.



10 things to know about...

Superbugs and genetics are some of the topics Teagasc researchers will be talking about in the upcoming TV series *10 things to know about...* to be broadcast on RTÉ this autumn, produced by New Decade TV. Antibiotics are an integral part of the agricultural industry; they are routinely added to the diets of pigs and poultry to try and prevent them from becoming sick. But, these animals can then act as a reservoir of resistance genes, increasing the likelihood of the spread of resistance, so is there another way?

At Teagasc Moorepark, Laura Boyle is exploring the link between animal welfare, antibiotic usage and antimicrobial resistance on Irish pig farms.

In 2014 and 2015, 60 New Zealand sheep were imported to Ireland to enable Teagasc researchers to compare the genetic differences between Irish and New Zealand sheep (see article on the INZAC flock on page 18). Nóirín McHugh and Fiona McGovern at the Teagasc research farm in Athenry describe how our Irish sheep fare against their kiwi cousins.

Barley is the fourth largest cereal crop after maize, rice and wheat, with 132 million tonnes produced annually. For thousands of years, barley has contained disease-resistant genes that are hugely important in terms of successful harvests, but 2017 has been a particularly bad year for the barley crop. Could a new technology called gene editing be the answer for Irish farmers? Plant geneticist Ewen Mullins will talk about our work in this area.



Nóirín McHugh with presenter Jonathan McCrea filming for 10 things to know about... in Teagasc Athenry.

Nurturing locally, growing globally – ICoMST 2017

The 63rd International Congress of Meat Science and Technology (ICoMST 2017), hosted by **TEAGASC**, took place in Cork recently.

Temple Grandin – welfare evaluations at slaughter

World-renowned animal behaviour expert Temple Grandin was one of the keynote speakers at the International Congress of Meat Science and Technology (ICoMST 2017) recently in Cork. Her talk focused on on-farm conditions that compromise animal welfare, and that can be monitored at the slaughter plant. She said that handling and stunning at slaughter plants has greatly improved through the use of numerical scoring. Her presentation encouraged the use of numerical scoring systems at the slaughter plants to assess conditions that compromise welfare, which occurred either during transport or on the farm. She explained: "Some of the transport problems that can be assessed are bruises, death losses, and injured animals. Welfare issues that occurred on the farm, which can be assessed at the abattoir, are body condition, lameness, lesions, injuries, animal cleanliness and internal pathology". She went on to say that there are important welfare issues that cannot be assessed at slaughter. They are on-farm euthanasia methods, use of analgesics during surgeries, and the type of animal housing systems. She stressed that welfare evaluations at slaughter have the potential to greatly improve welfare. Grandin is a designer of livestock-handling facilities and Professor of Animal Science at Colorado State University. Facilities she has designed are located here in Ireland and also in the United States, Canada, Europe, Mexico, Australia, New Zealand, and other countries. In North America, almost half of the cattle are handled in a centre track restrainer system that she designed for meat plants. Curved chute and race systems she has designed for cattle are used worldwide, and her writings on the flight zone and other principles of grazing animal behaviour have helped many people to reduce stress on their animals during handling. Grandin is also internationally famous as a spokesperson on autism and was the subject of the award-winning, semi-biographical film *Temple Grandin*.

Sustainable diets

The role of meat in strategies to achieve a sustainable diet lower in greenhouse gas emissions was presented by Maeve Henchion, Teagasc, Rural Economy and Development Programme. Henchion highlighted the complexities regarding sustainability in terms of meat consumption, and

possible strategies that could be implemented to mitigate its climatic impact. She outlined how sustainable diets are possible without the elimination of meat: "For instance, overconsumption of food in general, beyond our nutritional requirements, was found to be a significant contributor of emissions. Non-voluntary and voluntary mitigation strategies offer potential to reduce dietary greenhouse gas emissions. All mitigation strategies require careful consideration, but on-farm sustainable intensification perhaps offers the most promise. However, a balance between supply and demand approaches is encouraged. Health should remain the overarching principle for policies and strategies concerned with shifting consumer behaviour towards sustainable diets".

Alternative protein sources

Demand for protein is continuously increasing and despite advances in research and development of alternative protein sources, animal protein still holds a key role in the supply of this essential nutrient. Teagasc researcher Anne Maria Mullen explains: "Approximately half of the live weight of animals raised to produce meat is categorised as 'the fifth quarter', commanding lower market values than prime meat cuts. From the sustainability as well as from the protein quality points of view, it makes sense to explore the sources of high-quality protein already available, but not utilised to their fullest potential". Her talk summarised current opportunities for aggregating value to some of these protein-rich co-products from the meat-processing chain, underpinned by research advances on both technical and social aspects. The work is part of a large research initiative looking at the exploration of Irish meat processing streams for recovery of high-value protein-based ingredients for food and non-food uses – the ReValueProtein project.

CO in meat packaging

Carbon monoxide (CO) has many value-added benefits in meat packaging due to its colour-stabilising effects and enhancement of meat quality attributes. The regulation of CO within meat packaging varies worldwide and remains a topical and controversial issue. CO is prohibited in the EU for use in meat packaging mainly due to fears that it may mask spoilage, therefore misleading consumers. The issue of



consumer acceptance of CO was not considered. Teagasc's Lauren Van Rooyen explains: "Applying CO pretreatments prior to vacuum packaging enhances colour while allowing discolouration to occur by the use-by date, thereby addressing concerns about safety. Recent work showing European consumer acceptance of CO in meat packaging demonstrates its future potential within the EU. The information provided may support framing future policies intended to assure consumer protection, safety, choice and interest. Re-evaluation of permitting CO as a packaging gas within the EU may be warranted".

Award winners

Carlos Alvarez, a post-doctoral researcher in the Department of Food Quality and Sensory Science, Teagasc Food Research Centre, Ashtown, won runner-up in the International Meat Secretariat Prize at the Congress for his work on the ReValueProtein project.

Teagasc Walsh Fellow Jamie Cafferky, Department of Food Quality and Sensory Science, Teagasc Food Research Centre, Ashtown, won the ABP student award for best industry-relevant oral presentation at the Congress for his work on sensory and texture attributes of beef.

The main theme of the 63rd ICoMST was 'nurturing locally, growing

globally'. Teagasc's Assistant Director of Research and Congress Chair, Declan Troy, explains: "In addressing this, it was considered how science can offer the meat production and processing sector solutions to enable it to nurture sustainably at local level while offering opportunities to grow globally".

Acknowledgements

ICoMST 2017 took place at the Rochestown Park Hotel during August 13-18, 2017, and the organising committee was chaired by Teagasc's Assistant Director of Research Declan Troy. Teagasc acknowledges all the sponsors and especially the main sponsors of the event (ABP, Kerry, Meat Technology Ireland and University College Cork), and the work of the many Teagasc staff and students who contributed to its success.

Further reading

Over 450 papers were presented at the congress, many by Teagasc researchers.

Scientific papers are published in a special issue of *Meat Science* – <http://www.sciencedirect.com/science/journal/03091740/132?sd=1> – and the full conference proceedings have been published by Wageningen Academic Publishers – <http://www.wageningenacademic.com/doi/book/10.3920/978-90-8686-860-5>.

Authors

Catriona Boyle

Science Communication and Outreach, Teagasc Research Directorate, Head Office, Oak Park, Carlow
Correspondence: catriona.boyle@teagasc.ie



Pictured at ICoMST are (from left): Ciara McDonnell, Teagasc; keynote speaker Temple Grandin, Colorado State University, USA; Michael Creed, TD, Minister for Agriculture, Food and the Marine; and, Declan Troy, Congress Chairman, Teagasc.

Next generation biofuels



The Waste2Fuels project aims to convert food waste into high-value product, mainly biofuels, without competing with feed or food production. **TEAGASC** researchers are going to valorise the agri-food wastes and by-product from fermentation for biofuels by extracting high-value by-product from them using novel green extraction technologies.

One of the major challenges Europe will face in the coming decades is to make its energy systems clean, secure and efficient while ensuring European Union (EU) industrial leadership in low-carbon energy technologies. The production of sustainable biofuels that generate a clear and net greenhouse gas (GHG) saving without negatively impacting on biodiversity and land use is one of the main EU objectives. Low cost, good availability and supply, together with reasonable transportation and upstream processing costs to obtain fermentable sugars, are the most important factors to be taken into account when selecting biomass sources as raw materials for biofuels production.

Agri-food waste

One of the main untapped sources of biomass potential lies in agri-food waste (AFW). Each year in the EU alone, 89 million tonnes of food waste is produced. Recent reports from the Food and Agriculture Organisation of the United Nations (FAO) estimate that as much as 50% of the food produced globally is lost or wasted. Once other higher value valorisation routes have been realised, a huge volume of readily available, renewable, untapped biomass from the lower value fractions can be converted to an enormous amount of energy and high-value co-products. Organic crop residues, for example, including fruit and vegetable residues and processing by-products such as pulp, seeds and peels, pomaces and trimmings, and rejects, comprise an important source of sugar, lipids, carbohydrates, mineral acids, inorganic compounds, dietary fibres or phytochemicals (including phenolics, carotenoids and tocopherols), which can be valorised towards bioproducts and biocompounds. The remaining fractions are very high in cellulosic materials (cellulose and hemicelluloses) but low in lignin, making them potentially good for fermentation processes and, thus, for biofuel production. High sugar

content beverage wastes are also good candidates for fermentation. Assuming that about 0.1% of the yearly market flows in industrial wastewater streams (e.g., process wastewaters, seizures of badly-repaired or illegal goods, and stocks after their expiration date), about 70,000m³/year could be remediated in the EU. In fact, the disposal of waste beverages is a critical issue for the industry because of the cost of the treatment (up to €500/m³) due to the high COD (chemical oxygen demand) and the suspended solid concentration.

Waste2Fuels project

The Waste2Fuels project aims to develop novel and optimise existing technologies in order to convert unavoidable AFW (food waste and agricultural residues) streams into high-value products, like biochemicals and mainly biofuel – butanol – for use as a direct substitution for virgin fossil fuels (**Figure 1**). Butanol is one of the most promising biofuels due to its superior fuel properties compared to bioethanol and biodiesel, which are the main biofuels at the moment. In addition to its ability to reduce carbon emissions, its higher energy content (almost 30% more than ethanol), ability to blend with both petrol and diesel, lower risk of separation and corrosion, and resistance to water absorption, allowing it to be transported in pipes and carriers used by petrol, butanol offers a very exciting advantage for adoption, as engines require almost no modifications to use it.

Contributing to EU policies

The Waste2Fuels project has the potential to significantly reduce the burden on land use for biofuels not only in Europe but worldwide, along with dramatically improving conversion efficiencies of current biofuel production technologies. Moreover, it would significantly reduce the ever-increasing environmental problem of waste

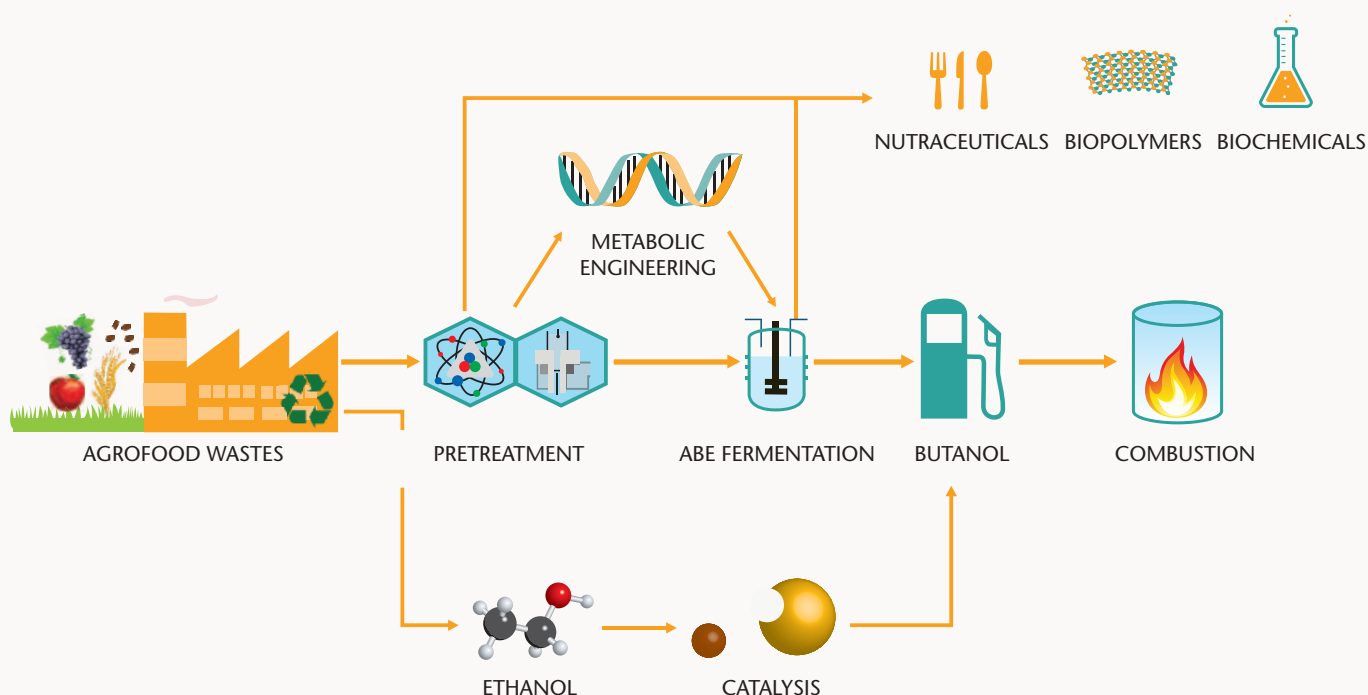


Figure 1: Waste2Fuels – a project for next-generation biofuels.

management and the landfill use for waste deposition. This is a very significant and timely development that can contribute to EU legislation specifying a reduction of GHG intensity of the fuels used in vehicles by up to 10% by 2020 – a low-carbon fuel standard. It will also contribute to the European policy target of reducing food waste by 50% and the 27% renewable energy target by 2030. Developing and optimising the AFW-to-fuel pathway would provide an immediate solution to the growing volumes of waste and create a sustainable, secure, stable and indigenous source of fuel for Europe with a positive energy balance. The waste-to-fuel (Waste2Fuels) technologies would also create opportunities for environmental and social gain by reducing the negative GHG implications of using fossil fuels. It would also contribute to the creation of significant employment opportunities – both directly in the conversion of waste streams into fuel and indirectly through feedstock preparation in the value chain, including increased sorting, capturing and recovering of biowaste.

Waste2Fuels aims to produce biobutanol as a sustainable alternative fuel contributing to decentralised energy production and towards EU energy security, and will enlarge the current biomass feedstock basis by the development of next-generation biofuel technologies capable of converting unavoidable AFWs into high-quality biobutanol. It is envisaged that by valorising 50% of the unavoidable and undervalorised AFWs as biomass feedstock for butanol production, we could potentially prevent up to 45 million tonnes of food waste ending up in EU landfills, preventing 18 million tonnes of GHG and saving almost 0.5 billion litres of fossil fuel. In doing so, Waste2Fuels would make a major contribution to leading the EU into the next generation of sustainable butanol, domestic bioenergy production and advanced AFW management.

Teagasc's contribution to the project

Another pathway to valorise the AFWs in the project is to extract high-value bioproducts, like nutraceutical components or biopolymer, from the AFWs. Designed as a sustainable technology, the by-product after butanol fermentation is also used to extract valuable components. Teagasc uses green novel extraction technologies, like power ultrasound-assisted extraction, microwave extraction, enzymatic extraction and their combinations to complete the extractions. These novel extraction technologies considerably increase yield, shorten extraction time, and reduce energy consumption.

Acknowledgements

The Waste2Fuels project is supported by Horizon 2020 (EU R&D programme) grant agreement no. 654623. For more on the project, see <http://www.waste2fuels.eu/>.

Authors

Zhihang Zhang

Researcher, Department of Food Chemistry and Technology, Teagasc Food Research Centre, Ashtown, Dublin 15
Correspondence: zhihang.zhang@teagasc.ie

Brijesh Tiwari

Principal Researcher Officer, Department of Food Chemistry and Technology, Teagasc Food Research Centre, Ashtown, Dublin 15





ProWelCow – dairy cow welfare

ProWelCow was a year-long desk-based project to identify risks and protective strategies for cow welfare associated with dairy herd expansion.

Irish systems of milk production have a marketing advantage over countries where milk is produced from housed cows. This is because consumers perceive pasture-based systems as more 'natural' and, therefore, better for cow welfare. While there is a lack of epidemiological data on cow welfare in pasture-based systems, Teagasc research demonstrated several welfare benefits associated with access to pasture (Olmos *et al.*, 2009). However, intensification in the dairy industry following the abolition of the EU milk quota regime means there is a risk that such advantages could be eroded (Boyle and Rutter, 2013).

In order to address these concerns, ProWelCow completed four tasks: 1) a survey to determine housing and management practices with implications for cow welfare (dairy farmers [n=115], cattle veterinarians [n=60] and Teagasc dairy advisors [n=48]); 2) a review of the Economic Breeding Index (EBI) in relation to welfare; 3) a review of Bord Bia's Sustainable Dairy Assurance Scheme (SDAS) and similar schemes abroad; and, 4) semi-structured interviews with 30 agri-industry stakeholders.

Current practices on Irish farms

The majority (77%) of farmers surveyed had increased their herd size in the previous three years. There was no more investment in housing or roadways on farms that expanded than on those that did not. Vets (90%) and advisors (87.5%) agreed that the best way to herd cows is on foot. More than 30% of farmers used quads/tractors to herd cows;

on those farms, herds were larger than herds where cows were herded on foot (152.7 vs. 99.0 cows). The lack of investment in roadways, combined with the potential for faster herding and longer walking distances in large herds, pose lameness risks. Furthermore, the lack of investment in housing poses risks of overcrowding; 32.9% of farmers provided <1 cubicle/cow. Low body condition score (BCS) was ranked as the main welfare issue by a higher proportion of farmers (72.2%) than vets (13.9%) or advisors (13.9%). More vets selected lameness as the main cause of poor welfare (28.3%) than farmers (13%) or advisors (2.2%). All stakeholders agreed that there are more threats than benefits to dairy cow welfare associated with dairy herd expansion.

The majority (77%) of farmers surveyed had increased their herd size in the previous three years. There was no more investment in housing or roadways on farms that expanded than on those that did not.

Breeding cows for better health and welfare

Many existing indicators of cow welfare do not fulfil the criteria for inclusion in the EBI because they are not easily or cheaply measured. Genetics can play a role in improving cow welfare by reducing the incidence of lameness and mastitis. Lameness and somatic cell count are in the health sub-index of the EBI. However, there is a case for strengthening the current weighting on lameness. Furthermore, the absence of data on clinical mastitis means that high accuracy of selection for mastitis itself is not possible.

Welfare was viewed by many as an essential component of the 'green Ireland' brand.

Evaluation of dairy assurance assessment schemes

Bord Bia's SDAS, the RSPCA/Freedom Food's AssureWel (UK), Friesland Campina's Cow Compass (NL) and Arla's Arlagarden (DK) were evaluated. All schemes claimed to assure cow welfare to a greater (e.g., AssureWel) or lesser (e.g., SDAS) extent. With the exception of the RSPCA's AssureWel, all schemes were deficient in assuring cow welfare because most of the indicators used were poorly defined and little information was provided to assessors on how to measure them. No scoring scales or sample size estimations were provided, and there was no information on their validity for on-farm use. Many of the schemes relied more heavily on the inspection of records than of the animals themselves. Critically, no animal-based indicators specific to pasture-based systems were identified in any of the schemes.

Stakeholder perceptions about cow welfare

Welfare was viewed by many as an essential component of the 'green Ireland' brand. Several stakeholders believed that poor cow welfare is not a problem, as they felt that measures are in place to protect animals. Such complacency poses risks to cow welfare. On the other hand, interviewees across several stakeholder groups recognised the potential threat to welfare posed by herd expansion and the focus on low-cost production. Poor financial viability and mental health challenges for farmers were also seen as risks to cow welfare. Increasing demands from international buyers were cited as the most important factor driving the focus on good cow welfare. Bord Bia's SDAS was well regarded, though some thought it should be extended to better address cow welfare issues. More focused training of advisors in cow welfare would improve their dissemination of relevant knowledge.

Acknowledgements

This study was funded by the Department of Agriculture, Food and the Marine's (DAFM) Research Stimulus Fund (14/S/890). Alison Rieple and Sylvia Snijders of the University of Westminster, London, UK conducted the social science component of the research.

Main findings:

- Poor BCS, overcrowding during housing and lameness are all potentially important causes of poor cow welfare in expanding, low-cost, pasture-based systems;
- In the short term, there is a pressing need for focused knowledge transfer on dairy cow welfare;
- In the medium term, research is required to identify animal-based indicators relevant to pasture-based systems, new welfare traits, new ways of deriving weightings for such traits and ways of improving routine access to data on these or correlated traits;
- Additionally, the current weighting on lameness in the EBI needs to be strengthened and animal-based indicators relevant to welfare (e.g., locomotion scoring) need to be included in the SDAS; and,
- In the long term, there is a need for investment in housing and infrastructure.

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Authors

Laura Boyle

Senior Research Officer, Pig Development Department, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Correspondence: laura.boyle@teagasc.ie

Joanna Marchewka

Post-Doctoral Researcher, Teagasc Moorepark (now Institute of Genetics and Animal Breeding of the Polish Academy of Sciences, Magdalenka, Poland)

Donagh Berry

Principal Research Officer, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

John Mee

Principal Veterinary Research Officer, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork



Dairy farming in the BMW region

TEAGASC researchers are investigating farm systems for the Border, Midland and Western region.

Irish dairy production has grown by almost a quarter since the end of EU quotas in 2015. In 2016, total domestic milk output reached 6,395 million litres and was valued at €3.4 billion to the national exchequer. Newly-released EU Commission figures reveal that, in stark contrast to static or decreasing milk production among larger member states, Ireland is currently producing 6.8% more milk each month when compared to 2016. Despite these impressive national trends, growth within the sector has not been evenly distributed nationally, with particularly significant growth in cow numbers in the south east (+33%) and midlands (+44%), and more modest increases in northern and western counties (26%).

The Border, Midland and Western (BMW) region of Ireland comprises 13 counties, including the six counties that border Northern Ireland, and accounts for 44% of the national land area. Notwithstanding its scale, the region currently accounts for only 20% of total national milk production (CSO, 2015). From an agronomic viewpoint, the wet mineral soils that are characteristic of the region impede drainage, and have been associated with a shorter grazing season and lower pasture production compared to the south and east of Ireland. Although PastureBase Ireland data indicate similar pasture productivity within the BMW region, National Farm Survey statistics reveal that average farm profitability ranges from 38-58% of that achievable on drier southern soils. In 2015, net subsidies accounted for 71.2% of agricultural income within the BMW region in comparison to 52% at State level (CSO, 2015).

The Ballyhaise dairy systems project

The main purpose of the Ballyhaise dairy systems research project in Cavan has been to develop highly productive grass-based systems of milk production that return a high level of profitability per hectare in this region. Since 2005, a number of multi-year farm systems studies have been undertaken at the Ballyhaise site.

While it is widely acknowledged that high-quality grazed grass is the cheapest and most profitable feed source for milk production, inadequate availability of grazeable land on the milking platform has hindered expansion for many dairy farmers in the region. As stocking rate is a key driver of the productivity and profitability of grazing systems, some producers have chosen to increase the milking platform stocking rate to levels that allow no silage production on the milking platform (in excess of 3.5 cows/ha), and are instead sourcing winter feed requirements elsewhere. While such stocking rates undoubtedly result in increased milk and revenue per hectare from the milking platform, the quantity and cost of purchased supplements that are required has not previously been reported, and hence an overall economic assessment of such systems has not been possible.

The objective of a recent four-year study at Ballyhaise was to investigate the economic sustainability of alternative pasture-based systems of milk production differing in terms of stocking rate, supplementary feed inputs and land availability on the milking platform.

Comparison of treatments

Two grazing platform stocking rate treatments were compared:

1. High closed feed system: 40ha milking platform, 124 dairy cows (3.1 cows/ha), 80% self-sufficient feed supply.
2. High open feed system: 40ha milking platform, 180 dairy cows (4.5 cows/ha), 50% self-sufficient feed supply.

Physical performance data was obtained based on a multi-year farm systems evaluation of each treatment on pasture production and utilisation, milk production per cow and per hectare, reproductive performance, and requirement for externally-sourced feed supplements.

Table 1: Effect of grazing platform feed system on purchased feed requirements and milk production performance.

Feed system	High closed	High open
Stocking rate (cows/ha)	3.1	4.5
Purchased feeds (kg DM/ha per year):		
Silage	1,917	5,796
Concentrate	1,708	3,924
Proportion of total feed purchased (%)	22	45
Milk production performance:		
Milk yield (kg/cow)	4,648	4,865
Milk yield (kg/ha)	14,190	22,229
Fat plus protein yield (kg/cow)	377	390
Fat plus protein yield (kg/ha)	1,153	1,786

A summary of the results is presented in **Table 1**. No significant influence of grazing platform stocking rate was found on body weight and body condition score or reproductive performance during the four-year study period. The strategic use of additional supplements with restricted pasture availability at the higher stocking rate maintained milk production per cow and significantly increased milk production per hectare. This increase in overall productivity, however, was explained exclusively by the increased nutrients supplied through additional silage and concentrate imports, while grass growth, quality and utilisation remained at similar levels for both systems.

Economic implications

The economic implications of the various treatments were also evaluated based on a 40ha milking platform, including current total dairy production costs (including full labour charges) and based on average, low and high expected future base milk prices (**Figure 1**). The results show that within a limited land area, increasing stocking rate from 3.1 to 4.5 cows per hectare and importing additional supplementary feeds reduces farm profitability at low and medium milk prices, with only marginal economic benefits at higher milk prices.

Implications for industry

In comparison with current average national statistics (763kg of milk fat plus protein/ha), the results of this analysis demonstrate the capacity for further increases in milk fat plus protein productivity on Irish dairy farms. Increasing stocking rate beyond the grass growth capability of the farm results in no additional pasture production, quality or utilisation benefit, and so any additional milk output is explained exclusively by additional nutrient supply through purchased supplements. The financial assessment indicates that

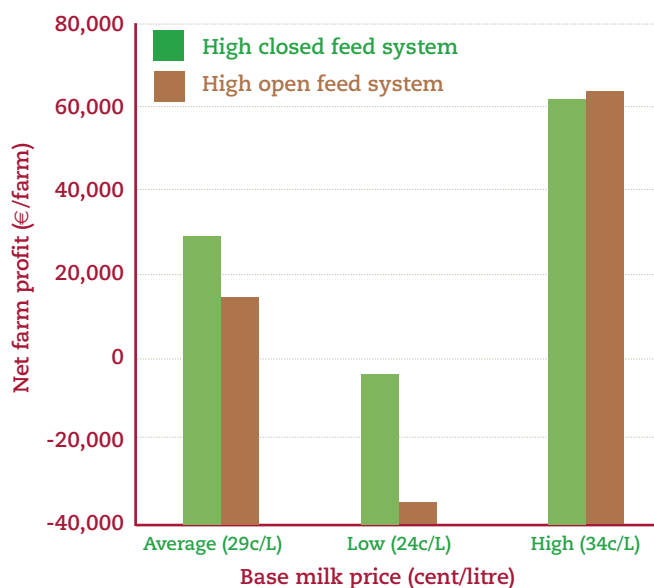


FIGURE 1: The effect of base milk price and pasture productivity on farm system profitability for alternative grazing platform feed systems.

increasing stocking rate on the grazing platform and maintaining animal performance with increased levels of purchased supplements has a negative impact on farm profitability at low and medium milk prices. The results reinforce the necessity for pasture-based dairy farmers to improve pasture productivity, allowing greater utilisation of grazed grass to expand milk production profitably. Any further increases in stocking rate must first be matched by improvements in pasture productivity and utilisation at farm level.

Acknowledgements

This research was funded by dairy farmers through Dairy Research Ireland. For more on PastureBase see: <https://pasturebase.teagasc.ie>. Follow @PastureBase on Twitter.

Authors

Donal Patton

Research Technologist, Ballyhaise, Co. Cavan.
Correspondence: donal.patton@teagasc.ie

Laurence Shalloo

Principal Research Officer, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Co. Cork.

Brendan Horan

Principal Research Officer, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Co. Cork.





Environmental enrichment for pigs

The use of different environmental enrichment options to prevent tail-biting in pigs is being investigated by **TEAGASC** researchers.

Pigs are highly motivated to perform exploratory behaviours. In commercial facilities these behaviours are often directed towards other pigs, particularly in times of stress. This results in tail-biting, an abnormal behaviour that is one of the most serious health, welfare and production problems in the pig industry. The consequences for pigs include pain, injury, infection and isolation, and for producers include lighter pigs, carcass condemnations, treatment costs, and additional labour and space requirements. Provision of adequate environmental enrichment not only reduces the risk of tail-biting but is also a legal requirement under current EU legislation (Council Directive 2008/120/EC).

In March 2016, the European Commission issued a recommendation regarding management of tail-biting in pigs, clarifying that enrichment materials should be edible, chewable, investigable, and manipulable, and should sustain the interest of the pigs (Commission Recommendation 2016/336).

Optimal enrichment materials (e.g., straw, hay, silage) possess all these characteristics, and are provided in the form of bedding. Irish pig production systems are almost all fully slatted, however, so these options are not possible. In fully slatted systems, alternative 'sub-optimal' materials, which conform to a subset of these characteristics (e.g., wood, ropes, compressed straw), are permitted, ideally with an optimal material provided in a rack. An ideal enrichment material should not only maintain or improve pig welfare, but should also improve the economics of the production system, and be practical to employ. We are carrying out the first research programme in Ireland aiming to identify commercially feasible enrichment options for pigs in fully slatted systems.

Producer survey

We carried out a survey (n = 58 producers; 90 to 3,000 sows/unit) to determine producer attitudes to tail-biting and enrichment. All respondents commented on the sporadic, unpredictable nature of tail-biting outbreaks, and the fact that there was no definite solution when it does occur. There was no correlation between herd size and the frequency of outbreaks, levels considered acceptable or perceived seriousness of tail- or ear-biting. When asked about an acceptable level of tail-biting, 82% of respondents stated that less than 2% of pigs should ever be affected. In the preceding year, 96% of respondents had observed tail-biting on their farm, and this occurred during all stages of production; 26% of responders reported tail-biting in first-stage weaners, 63% in second-stage weaners, and 72% in finisher pigs.

For 65% of respondents, the most common method of attempting to stop an outbreak was to add additional enrichment to the pen. For routine enrichment, chains were most commonly used. Wood was the most common organic material used, and straw/hay the least frequently used (**Figure 1**).

Wood was frequently mentioned as being particularly effective in reducing the rate, or intensity, of biting outbreaks, but there was concern regarding splintering, and damage to the mouth and internal organs.

Compressed straw blocks

We then carried out two experiments on a commercial farm investigating sub-optimal enrichments that may be appropriate for fully slatted systems. The first study investigated the feasibility of

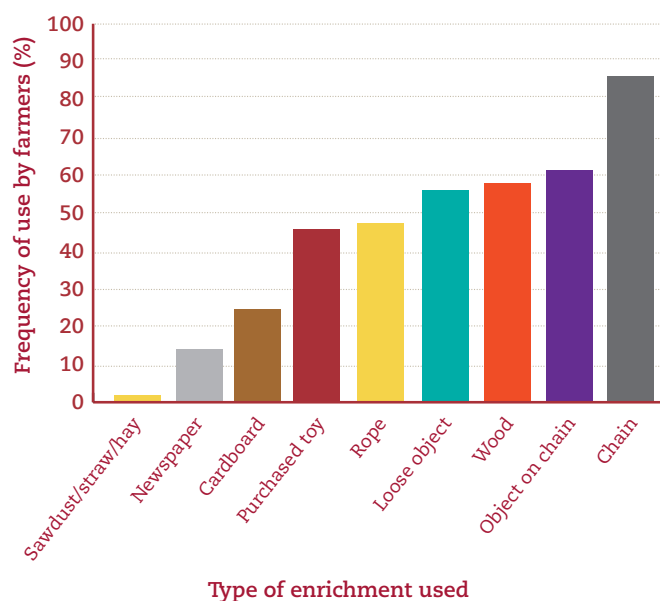


FIGURE 1: The percentage of respondents using the various types of enrichment material provided to pigs in Ireland.

supplying straw in the form of compressed blocks, dispensed through a holder on the wall (one holder/25 pigs). The study was from weaning to finish, and compared the blocks with hanging plastic toys. We saw no benefits of straw in any parameter used to assess welfare (tail and ear lesions, salivary cortisol level, reactions in open field and novel object tests, performance), or in lesions on the carcass in the factory.

Moreover, the blocks were prohibitively expensive, and labour intensive to manage. Based on the rate of use, we estimated a cost of approximately €20,000/year for every 500 sows in the herd to provide enrichment for all offspring through to the finisher stage.

Wood type

Although wood has been compared with other materials, there has been no published work investigating different species of wood. Our second experiment focused on the finisher stage, and compared wood from four tree species – spruce, larch, beech, and scots pine (control) – provided in the same style of holder as the compressed straw blocks.

Spruce was the softest wood, and was consumed more quickly (greater weight loss and reduction in length) than other wood types. Pigs interacted with the spruce more frequently than all other wood types, which could have contributed to this and indicates that it was more favourable to them. Nevertheless, there were no differences in the frequency of injurious behaviours (tail/ear/flank-biting), or in tail and ear lesions (levels were low in all treatments). Neither did we find any damage to the mouths of the pigs, nor differences in carcass quality related to the type of wood. When it came to cost, due to the different rate of wear, using spruce is considerably more expensive than the other species (Table 1).

Table 1: Annual cost of providing finisher pigs with beech, larch or spruce as environmental enrichment.

	Beech	Larch	Spruce
Price/kg	€1.67	€1.57	€1.71
Price/pig	€0.016	€0.039	€0.176
Price/year (finisher stage only):			
Per 500 sows in herd	€202	€504	€2,286

Conclusions

- Producers in Ireland are open to using wood as environmental enrichment, which is considered an appropriate enrichment type for slatted systems.
- Compressed straw blocks are not feasible in the manner that we provided them.
- Spruce, the softest wood, was most attractive to the pigs, and will be investigated further.

Acknowledgements

Rick D'Eath and Dale Sandercock of SRUC, Scotland, and Natalie Waran of the University of Edinburgh, Scotland, were involved in the experimental aspect of this project.

This study was funded by the Department of Agriculture, Food and the Marine Research Stimulus Fund (14/S/871). We thank all the producers who contributed to the survey, and who allowed us to carry out the experiments on their farms.

Authors

Keelin O'Driscoll

Research Officer, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork
Correspondence: keelin.odriscoll@teagasc.ie

Jen-Yun Chou

Teagasc Walsh Fellow, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Amy Haigh

Post-Doctoral Researcher (currently University College Dublin), Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork



Better genetics breed better lambs

TEAGASC researchers are comparing flock performance of elite genetic sheep flocks from New Zealand and Ireland and low-index Irish flocks.

The overall aim of the national sheep breeding programme is to produce low-cost, easy-care sheep with good maternal characteristics that will produce quality lambs with high growth rates, thus reaching slaughter at a younger age. This aligns with the Food Wise 2025 targets (the Irish Government's strategic plan for the development of the agri-food sector) for sheep breeding, and directly reflects the requirement of the farmer to maintain a profitable, efficient enterprise. However, the maternal characteristics of the Irish national flock remain sub-optimal, with average weaning rates reported to range from 1.3 to 1.43, and lamb mortality rates of over 15% reported in many flocks. Despite widespread evidence highlighting the positive impact of maternal sheep breeds on flock performance, the widespread use of terminal breeds in the national ewe population continues to exacerbate the low maternal performance of the national flock.

Genetics for breed improvement

Utilising genetics in animal production systems is a powerful method that enables farmers to select superior animals to become parents of future generations. Genetics involves the passing of genes (favourable and unfavourable) from parents to offspring; therefore, genetic effects are permanent and cumulative over time. The aim of the Sheep Ireland €uroStar index is to provide commercial sheep producers with an additional tool for the selection of genetically-superior breeding animals. Similarly, the New Zealand national genetic breeding programme allows producers to select animals with superior maternal characteristics. A recent study has shown that the rate of genetic gain achieved in New Zealand (€1.16/lamb per year) was more than four times higher than the genetic gain achieved in the Irish maternal index (€0.27/lamb per year). This has been a major contributor to New Zealand maintaining lamb output, despite a 50% reduction in their national ewe flock over the past

two decades. Therefore, the INZAC (Irish and New Zealand Across Country) flock was established with the dual objective of firstly validating the national maternal breeding index and, secondly, comparing Irish and New Zealand genetically-elite animals within an Irish grass-based production system.

INZAC research experiment

The INZAC flock was established at Teagasc, Athenry, Co. Galway, between 2014 and 2015, with the purchase of ewes and rams from Ireland and New Zealand. Irish-bred animals, originating from farms with a Sheep Ireland data quality index (DQI) of >60%, were selected based on the genetic potential of their parents, grandparents and great-grandparents within the maternal line for the replacement €uroStar index. New Zealand animals were within the top 30% of their dual-purpose index and had well-established links to the central progeny test farms within the New Zealand breeding programme. Ewes and rams were selected from a total of eight New Zealand farms, across both the north and south island, and from both upland and lowland enterprises. The flock consists of 180 ewes split into three treatment groups (n = 60): elite New Zealand ewes; elite Irish ewes (genetically superior); and, low-index Irish ewes (genetically inferior). Two main breeds, Texel and Suffolk, are equally represented within each experimental group, as shown in **Figure 1**. Texel and Suffolk represent the two most commonly-used terminal breeds within Ireland and, by default, Texel and Suffolk genetics also represent a large amount of the Irish commercial ewe population. The Texel and Suffolk breeds are also used within the New Zealand sheep industry and, therefore, were chosen for use within the INZAC flock.

The experiment commenced in autumn 2015 when the ewes were mated within their treatment groups using artificial insemination (AI), and will run for a four-year period. Although all INZAC animals

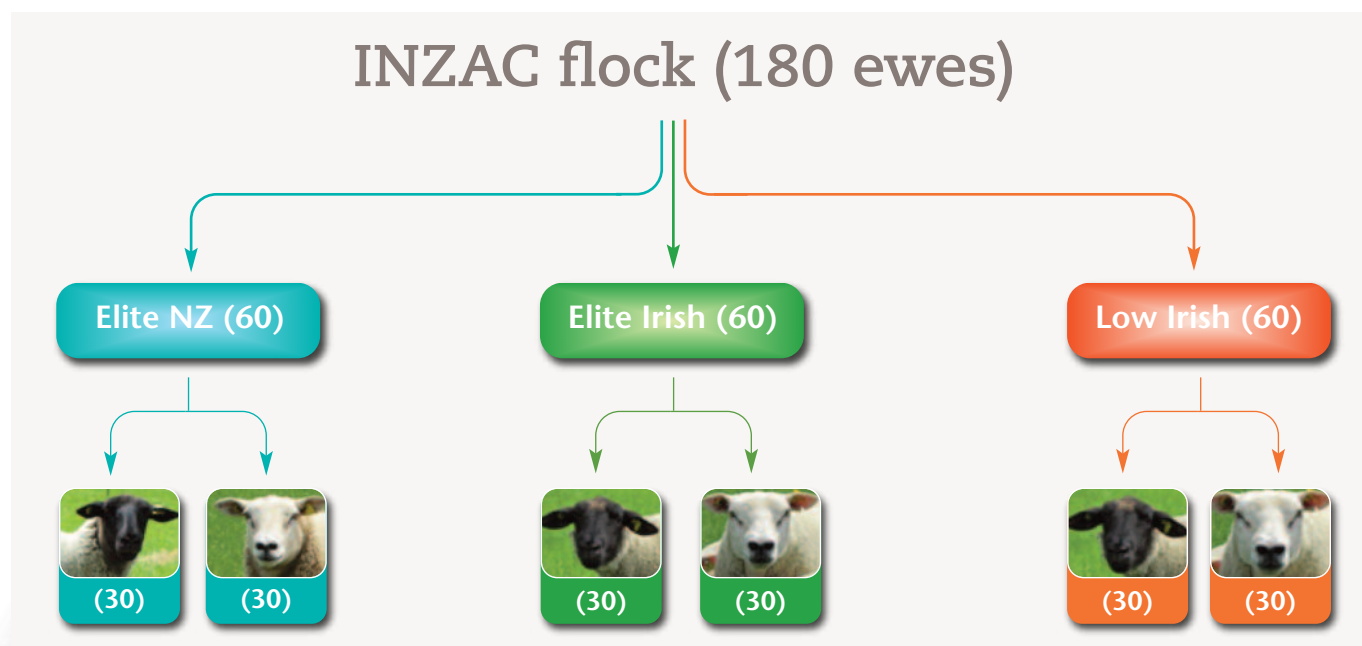


FIGURE 1: INZAC flock structure.

are pedigree animals, an objective of the flock is to maximise the proportion of grass in the flocks' diet; therefore, no concentrates are fed to ewes or lambs once animals are turned out to grass. The experiment is a systems study, with each group stocked at 12 ewes/ha and each paddock receiving 130kg of nitrogen (N) fertiliser/ha per year. Each treatment group is rotationally grazed throughout the grazing season (March to December). Throughout the study, various aspects of both animal performance (e.g., lambing difficulty, milk yield, ewe weight and body condition score (BCS), lamb weight) and grassland parameters (e.g., herbage utilisation and feed intake) are being investigated.

Animal performance results

Although the INZAC experiment is only in its second year of a four-year study, results to date indicate New Zealand ewes have had higher scanned litter sizes (1.85 vs 1.75 vs 1.66 for the New Zealand, elite Irish and low Irish ewes, respectively) and gave birth to lighter lambs with a lower lambing difficulty, when compared to the other two groups. Interestingly, the elite Irish and New Zealand ewes have higher lamb survival rates. Pre weaning, elite Irish and New Zealand lambs had a higher growth rate recorded within the first 100 days of life and were, therefore, heavier at weaning. The New Zealand and elite Irish ewes had higher measured milk yield than the low-index Irish ewes, which contributed to the superior lamb performance during the rearing period. Post weaning, lambs within the New Zealand and elite Irish groups had higher average daily gain (ADG), and subsequently higher lifetime ADG, when compared to the low-index Irish lambs. Consequently, low-index Irish lambs took significantly longer to reach target slaughter weight when compared to elite Irish lambs (14 days shorter) and New Zealand lambs (23 days shorter). This further resulted in a lower percentage of low-index Irish lambs being drafted from grass.

Results to date show that irrespective of origin, animals of high genetic merit outperform low genetic merit animals, thus highlighting the importance of genetic selection and the use of the Sheep Ireland maternal breeding index.

Acknowledgements

The authors would like to acknowledge funding from the Department of Agriculture, Food and the Marine (DAFM) and to thank the technicians and farm staff at Teagasc Athenry for their help throughout the experiment.

Authors

Fiona McGovern

Post-doctoral Researcher, Animal and Bioscience Research Department, Teagasc Animal & Grassland Research and Innovation Centre, Athenry, Co Galway
Correspondence: fiona.mcgovern@teagasc.ie

Nóirín McHugh

Research Officer, Animal and Bioscience Research Department, Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork





Ewe prolificacy and stocking rate

TEAGASC sheep researchers are investigating ewe prolificacy and stocking rate in grass-based lamb production systems.

The production of lamb in grass-based production systems is principally based upon the utilisation and conversion of herbage into lamb carcass. Successful grazing systems require animals that can efficiently convert feed into a high-value product. At present, lamb production systems are limited by the efficiencies at which they operate, such as the number of lambs weaned per ewe and the level of herbage utilised per hectare. In order to remain competitive, improvements in the efficiency of such systems are of paramount importance. Ewe prolificacy potential and stocking rate are two of the most influential factors affecting lamb output and the efficiency at which feed resources are utilised in grass-based lamb production systems.

Athenry research demonstration farm study

A prolificacy potential by stocking rate study, consisting of two ewe prolificacy potentials (medium prolificacy potential [MP; Suffolk X ewes; 1.5 lambs reared per ewe] and high prolificacy potential [HP; Belclare X ewes; 1.7 lambs reared per ewe]) and three stocking rates (SR): low (10 ewes/ha); medium (12 ewes/ha); and, high (14 ewes/ha) was conducted. Each group was managed in a rotational grazing system. Detailed measurements were undertaken with regard to animal performance and output, as well as the level of grass production and utilisation supporting the systems.

Biological performance and output

Table 1 shows the effect of ewe prolificacy level and stocking rate on lamb performance in terms of lifetime average daily gain and days to slaughter, as well as on total carcass output and the proportion of lamb carcass output achieved from grazed grass. Increasing stocking rate decreased individual animal performance and increased days to

slaughter. There was no difference in the days to slaughter data for the 10 and 12 ewes/ha groups, but days to slaughter were significantly higher for the 14 ewes/ha group. Prolificacy level had no effect on lifetime average daily gain or days to slaughter. There was no effect of prolificacy level on the proportion of lambs finished from a grazed grass-based diet. Stocking rate did have a significant effect on the proportion of lambs finished from grazed grass, with the lowest level achieved in the 14 ewes/ha group.

Ewe prolificacy potential and stocking rate are two of the most influential factors affecting lamb output and the efficiency at which feed resources are utilised in grass-based lamb production systems.

Grass utilisation

Table 2 shows the grass utilisation levels for the systems and what it means in terms of grass utilised per hectare, per ewe and per kilogram of lamb carcass produced. The important point to note here is that a significantly higher quantity of total dry matter (DM) was required to support the 14 ewes/ha group compared to the 10 and 12 ewes/ha groups on a per ewe basis. This was largely due to

Table 1: The effect of ewe prolificacy potential and stocking rate on biological performance and output.

Parameter	Prolificacy		Low	Stocking rate	
	Medium	High		Medium	High
Lifetime average daily gain (g/day)	218	216	231	219	200
Days to slaughter	215	215	203	213	230
Total lamb carcass produced (kg)	346	396	321	368	424
Proportion of lamb carcass produced off grazed herbage	0.85	0.85	0.91	0.85	0.79

Table 2: Effect of ewe prolificacy potential and stocking rate on grass utilised per hectare, per ewe and per kg of carcass produced.

Parameter	Prolificacy		Low	Stocking rate	
	Medium	High		Medium	High
Grass utilised (kg DM/ha)	10,449	10,347	8,306	10,038	12,849
Grass DM utilised/ewe (kg)	864	859	831	837	918
Grass DM/kg carcass (kg)	30	26	26	27	31

the higher days to slaughter for lambs at this stocking rate level group, which required feeding for longer compared to the lower stocking rate groups. There was no effect of ewe prolificacy level on herbage DM production or utilisation.

Results from this study demonstrate high prolificacy ewes to be more efficient in the production of lamb.

System efficiency

The higher demands from the extra lambs within the high prolific systems (+0.2 lambs/ewe) would appear to be cancelled out by the lower maintenance requirements of the high prolific ewes, due to their lower mature bodyweight compared to the medium prolific ewes. On an efficiency basis, taking into account the total kilograms of lamb live weight weaned per kilogram of ewe live weight mated, the high prolificacy potential ewes were 5% more biologically efficient, which is additional to the direct benefit of prolificacy.

Implications for industry

Results from this study demonstrate high prolificacy ewes to be more efficient in the production of lamb. Increasing stocking rate provides the opportunity to increase lamb carcass output per ha;

however, achieving this increase in output required additional grass DM per ewe and lamb unit above 12 ewes/ha. The appropriate stocking rate for a farm will be dictated by its grass-growing potential to support a given stocking rate. Increasing ewe prolificacy should always be the first priority, while increasing stocking rate must always be done in conjunction with increased grass production and utilisation.

Acknowledgements

This research was funded through the Teagasc Walsh Fellowship Scheme.

Authors

Philip Creighton

Research Officer, Teagasc, Animal & Grassland Research and Innovation Centre, Athenry, Co. Galway
Correspondence: philip.creighton@teagasc.ie

Elizabeth Earle

Walsh Fellow, Teagasc, Animal & Grassland Research and Innovation Centre, Athenry, Co. Galway and UCD.



Improving soil organic carbon



Soil organic matter is important for maintaining a healthy environment for plants and soil micro-organisms. Its main constituent, soil organic carbon, plays a vital role in removing CO₂ from the atmosphere. **TEAGASC** researchers are investigating how to improve retention of soil organic carbon.

Why care about soil quality?

Soil organic matter (SOM) forms due to the decomposition of plant and animal residues that enter the soil system. These inputs include leaf and straw residues, root material, soil biota, and any applied animal manure. Soil organic carbon (SOC) is the main constituent of SOM, accounting for 50% of the total, and sequestration of carbon (C) in soils plays a vital role in removing CO₂ from the atmosphere. Indeed, global soils contain 2,200 billion tonnes of carbon, three times the amount in the atmosphere. SOM is also rich in nutrients such as nitrogen (N), phosphorus (P) and sulphur (S), and in micronutrients, and SOM increases have been positively related to soil fertility and agricultural productivity potential. SOM/SOC consists of an active labile pool, which is readily available to soil organisms, and a passive pool (humus), which is hard to decompose. Sequestration of C occurs when there is a build-up in the passive pool, while the labile pool is most associated with the nutrient effects of SOC.

Role of SOM in plant productivity

The role of SOM in enhancing plant productivity can be classified into three broad categories: biological, physical, and chemical. SOM contributes soil nutrient retention by increasing the cation exchange capacity (CEC), which determines a soil's ability to retain positively-charged plant nutrients. Thus, SOM can act like a slow-release fertiliser. SOM also plays a key role in soil aggregate formation, which reduces soil bulk density and compaction. As a result, it also increases the soil's water-holding capacity. SOC also provides an energy source for soil microbes and fauna. These are vital for decomposition and soil nutrient cycling.

Increasing organic C in croplands

Cropland soils generally store less SOC than grassland because cropland has greater disturbance from cultivation, a lack of organic manure being returned to the system, has a winter fallow period and, as a consequence, has less root and shoot material returned to the soil. Changes in SOM/SOC are not linear and reach a new equilibrium over time (**Figure 1**). In other words, accumulation of SOM/SOC is finite. Some examples of management options to increase organic carbon C in croplands are:

Cover crops/rotations

Crop rotations can include cover crops, perennial grasses and legumes that maximise soil C inputs and maintain a high proportion of active C.

Straw and manure incorporation

Straw incorporation increases SOC, as organic matter is directly inputted back into the soil. **Figure 1** shows that for 4t straw incorporated over 20 years, a 7-17% increase in SOC (top 15cm only) has been observed (depending on whether reduced tillage was also applied). Manure inputs will also build SOC stocks, particularly farmyard manure.

Reduced/minimum tillage

The concept of reduced tillage is that aggregates are disrupted less, leading to reduced SOC loss. However, while SOC levels in the top 30cm are increased, there is increasing evidence that ploughing may simply redistribute SOC over a greater depth profile.

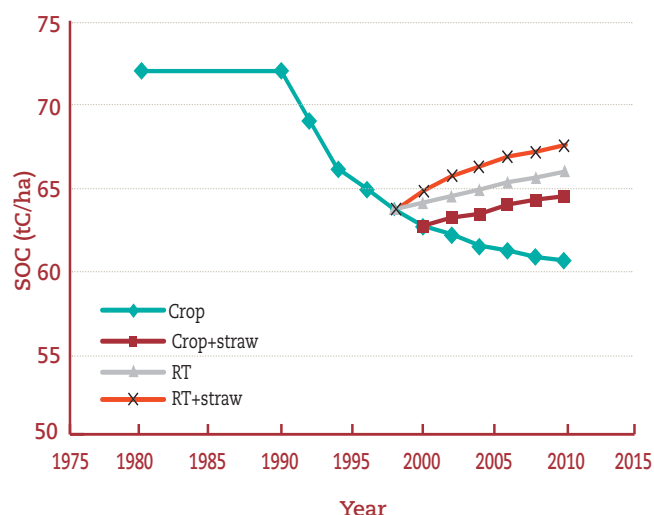


FIGURE 1: Impact of grassland conversion to cropland and subsequent impact of management on soil organic carbon.

Increasing organic carbon in grassland

Soil quality in grasslands could be improved by achieving a 'right' balance between C and N inputs to soils. A combination of agricultural practices that promote the formation of stable soil aggregates will improve soil quality and sustainability. Some management options include:

- In permanent grasslands (>5yrs) a key step is to improve either organic or inorganic fertiliser management. A first step would be to combine liming treatments with either organic and/or inorganic nutrient fertilisation (N, P, K, Mg, etc.). In terms of temporary sown grasslands (<5yrs) and renovation via ploughing, a key step is to increase the time between re-seeding to at least five years, as this will contribute to an organic matter build-up though reduced tillage events.
- Increasing the abundance of legume species in some grass swards can improve sequestration and forage quality, and reduce inorganic N inputs. In combination with legumes, a more diverse vegetation cover (>4 species) can make grasslands more resilient in terms of climate change, and may provide both a better forage quality and organic matter input.
- A third step is to reduce frequency of use of heavy machinery, which could cause high soil compaction and thus 'reduce' pore space available in the soil matrix, which is necessary to transport and accumulate extra C (via soil climate, macro fauna, earthworms, microbes, etc.). Animal grazing is

preferable to silage/hay production, due to the nutrient recycling of animals and the reduction in work (25-40% of ingested herbage is returned to the pasture in excreta).

- Finally, the development of pasture management plans, perhaps around a five- to seven-year cycle, where a combination of different practices (liming, nutrients, grazing, reseeded) guarantee balanced applications of C and N to soils under moderate (soil) disturbance (avoid high animal stock densities and intensive mowing). A soil monitoring programme including analyses of soil C and N content, soil bulk density and pH should be put in place and run every two to three years.

Summary

- Soil organic matter (SOM) and soil organic carbon (SOC) levels in arable systems are lower compared to grassland systems due to ploughing and fallow periods.
- Improving SOM will increase aggregate stability, and reduce compaction, erosion and nutrient leaching, as well as increasing soil fertility by improving nutrient availability.
- Furthermore, carbon sequestration associated with SOM build-up will offset greenhouse gas emissions but is also reversible.

Acknowledgements

This study was funded by the Department of Agriculture, Food and the Marine's Research Stimulus Fund (RSF 10/RD/SC/716).

Authors

Gary Lanigan

Principal Research Officer, Crops Environment and Land Use Programme, Teagasc, Johnstown Castle, Wexford.
Correspondence: gary.lanigan@teagasc.ie

Richie Hackett

Research Officer, Crops Environment and Land Use Programme, Teagasc, Oak Park, Carlow.



PAT approach for cheese manufacture

Researchers at **TEAGASC** and UCD are validating a prototype in-line sensor to control and monitor the cutting of milk coagulum at optimum condition during cheese manufacturing.



Ireland exports 85% of all dairy outputs and is the 10th largest dairy exporting nation in the world. Considering the huge contribution of cheese exports to the Irish dairy sector (worth €695 million in 2016), it is essential to ensure the quality and consistency of the cheese being produced. This can be achieved by adoption of process analytical technologies (PAT) in the dairy factory, as it encourages process efficiencies by in-line, real-time monitoring and control of the cheese manufacturing process.

Optimum cutting time for cheese quality

Cheese manufacturing involves several steps that contribute to the quality of the cheese produced. Standardisation of milk and coagulation are the earliest critical points where the quality of the cheese can be monitored and controlled. Ongoing studies at Teagasc Food Research Programme, Moorepark, have focused on the control and optimisation of the coagulation process. Coagulation of milk can be described as the transformation of milk into a semi-solid coagulum by the action of rennet, a proteolytic enzyme (**Figure 1**). Depending on the type of cheese produced, the coagulum formed requires cutting at an optimal firmness linked to a particular curd structure. If the coagulum is cut too early, a soft fragile network is formed. This results in increased curd fines (small particles that are not recovered in the cheese) and fat loss during syneresis (the process where liquid whey is expelled on stirring the cut coagulum), leading to reduced final cheese yield. In contrast, a delayed cutting time produces an overly firm gel, in which the network is unable to

rearrange, resulting in retarded syneresis and increased curd moisture, compromising finished product quality. In most cheese plants, the coagulum formed is cut after a predetermined time, whereby optimal coagulum properties have been achieved. It can also be determined subjectively based on evaluation of textural and visual properties of the curd. It is essential to monitor coagulum firmness and cutting time in every cheese vat to ensure a consistent product, which has driven the need for robust in-line PAT to support cheese processes. Several off-line, at-line, on-line and in-line devices have been studied for monitoring both coagulum firmness and prediction of cutting time in the cheese process. Existing PAT, including hot-wire probes and near infrared (NIR) reflectance probe sensors, are used in commercial plants to monitor coagulation kinetics and predict optimal cutting conditions. Although these in-line tools are efficient in predicting coagulation kinetics, it is reported that they have poor prediction accuracy in respect to compositional changes such as varying protein content.

Research using in-line PAT sensor

Current research in Teagasc and UCD is focusing on the validation of a prototype in-line PAT sensor based on combined NIR reflectance and fluorescence probes operating synergistically to monitor coagulation kinetics of milk. Changes occurring in the milk matrix during coagulation correlate with differences in output signals from both probes. NIR reflectance data provide real-time monitoring of particle size distribution and formation of gel structure. As casein

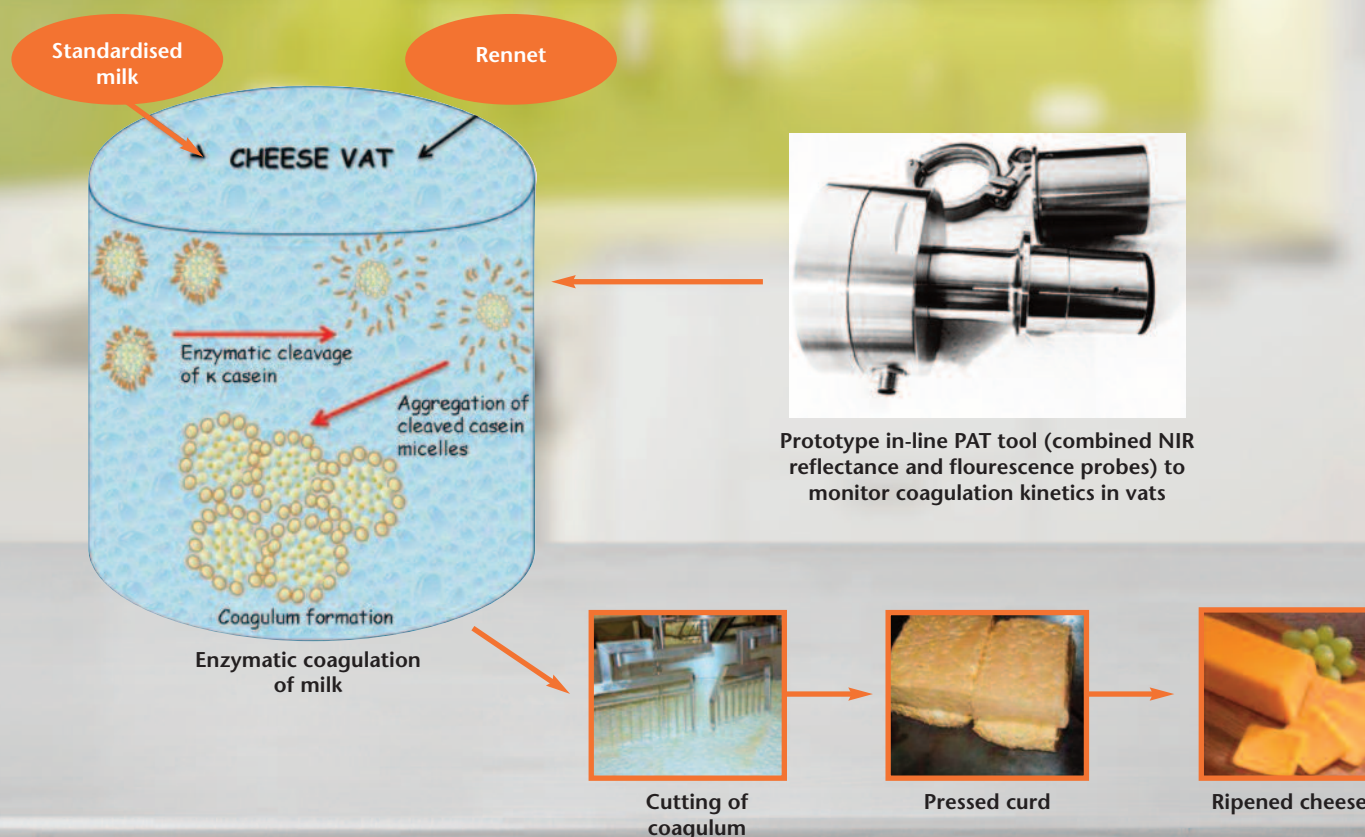


FIGURE 1: Enzymatic coagulation of milk and the PAT tools used to monitor the process.

micelles aggregate forming larger particles, there is a shift in particle size distribution that leads to increased reflectance during coagulation of milk, while the fluorescence probe, which measures the fluorescence emitted by tryptophan, monitors changes in the signal impedance linked to the formation of the coagulum.

Optimum conditions at industry level

Validation of the optimal cutting conditions obtained from the sensor was performed using rheological tests that provide accurate information on optimal cutting characteristics, based on the firmness and strength of the coagulum formed. The time points at which changes were recorded in the output signal from the sensor correlated with the gelation point obtained from the rheological test. The data points from the sensor and rheological method were used in developing a prediction model to predict the optimal cutting time in model systems. Final validation of the sensor at industrial level is underway. With ongoing development of robust prediction models, the in-line PAT sensor, combining NIR reflectance and fluorescence probes, has the potential for optimisation of cutting time, compared to existing technologies, therefore improving batch-to-batch consistency in Irish cheese plants.

Acknowledgement

This work is supported by the Irish State through funding from the Dairy Processing Technology Centre research programme funded by Enterprise Ireland (Grant Number TC/2014/0016).

Authors

Bhavya Panikuttira

PhD researcher, School of Biosystems and Food Engineering, University College Dublin and Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork

Norah O'Shea

Post-doctoral Researcher, Food Chemistry and Technology Department, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork

Colm P. O'Donnell

Professor and Head, School of Biosystems and Food Engineering, University College Dublin

John T. Tobin

Head, Food Chemistry and Technology Department, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork

Correspondence: john.tobin@teagasc.ie



Leading the *whey* in tackling obesity



TEAGASC researchers provide an update on their investigations into the underlying mechanism for the anti-obesity effect of whey proteins.

A team of researchers led by Kanishka Nilaweera has published a series of articles in *TResearch* in recent years detailing their work on assessing how dietary whey proteins reduce body weight gain. This article summarises recently published data that extends their previous work by showing an underlying mechanism for the above effect. This work will pave the way for the creation of dietary interventions that can contribute to preventing or curing the development of obesity.

Worldwide obesity problem

The prevalence of obesity worldwide has doubled since 1980. According to a Health Ireland survey in 2015, 60% of the population aged 15 years and over are now either overweight or obese. This is a major health problem because it increases the risk of development of several clinical conditions, such as diabetes and cancer. This highlights the need to develop suitable interventions to cure or prevent the development of obesity.

Healthy weight for Ireland plan

Given these trends and health implications, the Irish Government published a ten-year policy and action plan for 2016 to 2025 (Department of Health, 2016) to reduce the number of overweight and obese individuals in this

country. This approach was developed following consultation with a wide variety of governmental and non-governmental organisations, including the general public. Importantly, it sets out the “Ten Steps Forward” action plan and additional actions to support the above steps. A key step in this regard is to “embed multi-sectoral actions on obesity prevention with support of Government departments and public sector agencies”. Teagasc is committed to this process through the ‘Vision Programme on Obesity’ by providing valuable knowledge on how obesity develops and, in turn, developing interventions to prevent or cure this disease.

WPI reduced weight gain and fat mass. Notably, the intestinal expression of genes involved in glucose transport and fatty acid transport were reduced. Additionally, the composition of gut microbiota was also altered.



Intestine and body weight regulation

The role of the intestine in body weight regulation is well established, given its role in the production of satiety hormones, as well as in nutrient absorption via specific nutrient transporters. The intestine also harbours a large quantity of microbes, and their importance for body weight regulation has been shown using germ-free mice (i.e., mice that have no microbes in their gut). Notably, these mice show reduced fat mass despite consuming more food than conventionally raised mice (which harbour a normal complement of gut microbiota). The data suggest that microbes play an important role in supplying nutrients to the host, since in the absence of this contribution (as in germ-free mice), the mice adapt by consuming more food. Given the interaction between nutrients, intestine and gut microbiota for body weight regulation, one could then envisage that changes to one component (for instance, the diet) would profoundly affect how other components in this chain influence body weight.

Our data suggest that combining low sugar (sucrose) with whey protein intake may help the general public to gain less weight, and turn the obesity tide.

Anti-obesity potential of dietary whey proteins

Our interest in exploring the anti-obesity potential of whey proteins started in 2012. Since then, we have published a number of research papers exploring how whey proteins reduce weight gain, which we have summarised in articles published in *TResearch* in 2013, 2014 and 2016. Notably, this work led us to focus attention on the intestine as a key mediator of the whey protein effects. Additionally, our previous data suggested a potential interaction between whey proteins and carbohydrate in the diet that could further influence body weight gain. However, it wasn't clear from this work if the interaction related to sucrose content in the whey protein diet. To further investigate this, we designed an experiment to assess whether whey proteins could influence key intestinal components involved in nutrient absorption and if there is an interaction between whey proteins and sucrose that can modify the intestinal components (gut microbiota and nutrient transporters) regulating body weight. Mice were fed a diet with whey protein isolate (WPI) with either high or low sucrose for 17 weeks; the controls received the same diets but with casein (Nilaweera *et al.*, 2017). Irrespective of the sucrose content, animals given WPI had reduced weight gain and fat mass. Notably, intestinal expression of genes involved in glucose transport and fatty acid transport were reduced. Additionally, the composition of the gut microbiota was also altered, where certain

populations linked to the development of obesity were found to be reduced in abundance in the WPI group. Notably, there was an interaction between sucrose content and WPI, whereby lowering the sucrose content in the WPI diet increased energy expenditure (without further affecting the intestinal transporters and the gut microbiota). This further reduced weight gain and fat mass. The data suggest that WPI affects intestinal mechanisms controlling nutrient absorption (nutrient transporters and the gut microbiota), and that by modifying the sucrose content in the WPI diet, there is a further independent effect on fat mass.

Relevance to policymakers and the industry

A key action plan of the above policy document produced by the Department of Health is to develop ways to reduce sugar content in the diet. Our data suggest that combining this strategy (low sugar [sucrose]) and taking whey protein may help the general public to gain less weight, and turn the obesity tide.

Acknowledgments

This work was funded by Teagasc (core funding and the Walsh Fellowship scheme) and by the Science Foundation Ireland-BBSRC grant (SFI/16/BBSRC/3389). Related research in the Cotter laboratory is funded by a Science Foundation Ireland-PI grant (SFI/11/1137). The team included researchers from Teagasc, University College Cork and the University of Aberdeen, UK, as detailed in the publication below.

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Authors

Kanishka N. Nilaweera

Research Officer, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork
Correspondence: kanishka.nilaweera@teagasc.ie

Paul D. Cotter

Research Officer, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork





The benefits of whey

Researchers at **TEAGASC** are formulating antioxidant beverages based on bovine whey.

Whey is a milk protein prized for its health-promoting benefits. The biological value of whey is higher than egg and meat protein. Bovine whey contains the proteins β -lactoglobulin, α -lactalbumin, bovine serum albumin, lactoferrin and immunoglobulins. Bovine whey provides a complete protein source, and is rich in sulphur-containing amino acids and branched chain amino acids. Demand for high-quality whey proteins is expected to increase as consumers realise their health benefits beyond the sports nutrition market. For example, food scientists have looked at whey as a potential antioxidant. Dietary antioxidants may help us to live longer in good health by reducing the incidences of neurodegenerative disorders, cancer and liver damage.

Here at Teagasc Food Research Centre Moorepark, we investigated the antioxidant activity of commercial whey products and whether this bioactivity survives gut transit. The ultimate aim of the project was to produce nutritional beverages enriched with whey that are suitable for the ageing consumer.

Of particular interest for the Irish food export market, we have generated powder products from these formulated beverages using spray drying.

Antioxidant activity of whey after digestion

Commercially available whey products (such as whey protein isolate and whey protein concentrate) were subjected to *in vitro* simulated conditions of stomach and duodenal stages of digestion. We used three different methodologies to determine the antioxidant activity of

native and digested whey samples: oxygen radical absorbance capacity (ORAC); radical cation decolourisation assay (ABTS); and, ferric reducing ability of plasma (FRAP). The results obtained with ORAC assay showed that whey proteins, particularly α -lactalbumin, exhibited antioxidant activities, which were increased during gut transit (**Figure 1**). These results were confirmed with ABTS and FRAP experiments.

To identify individual protein fragments (peptides), ultra-performance liquid chromatography/electrospray ionisation-high resolution tandem mass spectrometry (UPLC/ESI-HR-MS/MS) was performed. Interestingly, we observed that several known bioactive peptides were released during gut digestion, and these peptides exhibited antioxidant activity. It is, however, important to realise that although whey is antioxidant and this activity is comparable to other proteins, it is not as strong as other well-known compounds such as polyphenols or carotenoids. Although whey can be used in food products at much higher concentrations than these antioxidants, its activity is unlikely to be comparable to these compounds.

Health benefits of whey peptides

Our studies also looked at which whey peptides and amino acids are transported across the intestinal barrier into the bloodstream to reach target organs like muscle and the liver. To do this, we optimised an *in vitro* model of the intestinal barrier, including enterocytes and mucus-producing cells (Caco-2/HT-29 co-cultures). These co-cultures are a good model to analyse bioavailability of food components. Bioavailability is defined as the portion of the digested food that reaches the blood circulation and is available to downstream target cells. Analysis of whey samples after absorption through the intestinal barrier model revealed not only amino acids but also several peptides. Some of these peptides were already known as bioactives but some were novel. We are now screening these



Elena Arranz and Alberto Corrochano are part of a team hoping to produce whey-enriched beverages that are suitable for the ageing consumer.

novel peptides for health benefits such as muscle repair, nerve health, weight management and cell antioxidant promotion.

Whey-based beverages formulation

At pilot plant scale, we have also formulated whey-based beverages, suitable as a 200ml single serving for the elderly consumer. To boost antioxidants, we have combined whey in these formulations with plant polyphenols and algae carotenoids. Moreover, and of particular interest for the Irish food export market, we have generated powder products from these formulated beverages using spray drying. At present we are studying the antioxidant shelf life of the beverages and powder products.

Acknowledgements

Funding for this project is provided by the Department of Agriculture, Food and the Marine, through the FIRM programme (WheyGSH (13/F/354)). Alberto R. Corrochano is funded under the Teagasc Walsh Fellowship scheme.

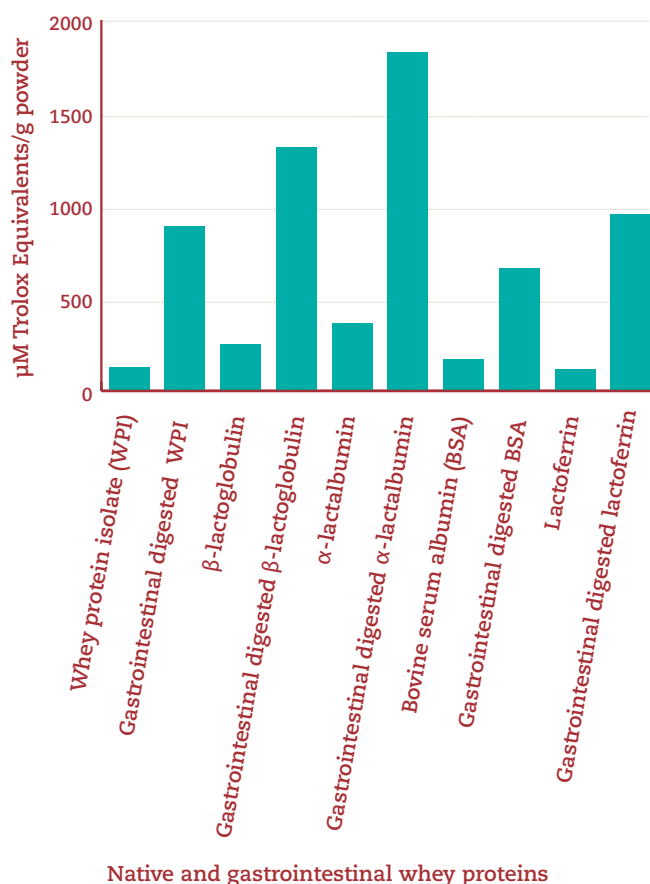
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Native and gastrointestinal whey proteins

FIGURE 1: Antioxidant results (ORAC assay) of native and gastrointestinal digested whey proteins.

Authors

Linda Giblin

Senior Research Scientist, Food Biosciences Department, Food Research Centre, Teagasc, Moorepark, Fermoy, Co. Cork
Correspondence: linda.giblin@teagasc.ie

Elena Arranz

Research Officer, Food Biosciences Department, Food Research Centre, Teagasc, Moorepark, Fermoy, Co. Cork

Alberto R. Corrochano

Walsh Fellow, Food Biosciences Department, Food Research Centre, Teagasc, Moorepark, Fermoy, Co. Cork





Proteins of the future

TEAGASC researchers are exploring opportunities for a more sustainable supply of protein as part of the ReValueProtein project.

Despite the fact that the protein needs of the growing global population, from a nutritional perspective, can be met by existing supply levels, the projected growth in demand for protein will require more sustainable and novel sources of supply. A recent paper published by Teagasc researchers in *Foods* (Henchion *et al.*, 2017) reviews current and potential future sources of protein, considering nutritional, environmental, technological and market/consumer factors.

It concludes that varying protein sources will be important for the future but that there are significant, and somewhat different, challenges in realising their potential as sustainable sources, and in ensuring food security.

Vegetal sources

Vegetal sources currently account for the vast amount of protein supply globally (57%); meat (18%), dairy (10%), fish and shellfish (6%), and

other animal products make up the remainder. Cereal proteins are particularly important in the human diet in developing countries; however, some plants do not contain high amounts of proteins (e.g., rice) and many lack one or more essential amino acids. Combining different protein sources and dietary supplements are two options to address this deficiency for individuals who want to increase the proportion of vegetal protein in their diets. Coeliac disease (auto-immune disease) and non-coeliac gluten sensitivity limit the role of such protein sources in some populations.

Cereals can offer additional health benefits due to the presence of bioactive peptides, which are known to have antioxidant, anti-inflammatory, cholesterol-lowering, satiety, anti-diabetic and other health benefits.

Plant-based protein is preferable to animal-based protein from a land-use and greenhouse gas emissions perspective, but high-intensity plant protein production has negative associations regarding water use, soil degradation and pollution.

Emerging protein sources include pulses, insects, algae and *in vitro* meat. Many of these offer significant environmental benefits; however, net environmental benefits cannot be assumed.

Animal sources

Concerns about animal-based protein relate to greenhouse gas production, land, water and energy use, biodiversity loss, and social and public health impacts. Many improvements have already been made in these areas as a result of better breeding, feeding and management; however, adoption of such technologies and practices is still low, and there is a need for significant knowledge transfer initiatives to be undertaken globally to achieve increased efficiency. On the positive side, animal-based protein is seen as important from a nutritional perspective and ruminants in particular have an important role in relation to food security, converting fibrous material, e.g., grass, which cannot be digested by humans, into high-quality protein. Animal-based protein is also generally well accepted by consumers and has a significant role in diets, lifestyles and culture. While there is some evidence of initiatives aimed at reducing animal-based protein consumption in developed countries, and meat and dairy production is restricted for religious reasons in some societies, animal-based protein is generally seen as “natural, normal, necessary and nice” (Piazza *et al.*, 2015). Livestock production is also important from an economic perspective in developing countries and, more locally, it is very important to Ireland’s rural economy, providing significant social benefits in such areas.

Emerging protein sources

Emerging protein sources include pulses, insects, algae and *in vitro* meat. Many of these offer significant environmental benefits; however, net environmental benefits cannot be assumed. Ethical benefits, e.g., animal welfare and the opportunity to develop products with high value added, are other benefits cited by supporters. Food safety, technical difficulties, production costs, and consumer issues present some challenges. Consumer attitudes towards many of these have not yet been fully formed due to their novelty; how these develop will clearly have a significant influence on adoption levels.

Future demand for protein

Given the projected growth in the global population, along with increased urbanisation and lifestyle changes, the future demand for protein is expected to increase significantly. Many sources of protein will be required to ensure that this demand is met in a sustainable manner and this will require a shift away from viewing sources of protein as ‘good’ or ‘bad’. Determining the optimum mix of sources will be a significant challenge, with great care required to ensure fair and appropriate comparisons between different sources and to give due consideration to economic, environmental and social aspects. All the necessary knowledge to make such decisions is not yet available. While life cycle assessments have indicated that plant-based diets use less land, for example, than animal-based diets, land use optimisation models have reported different results. Related research which finds that certain livestock systems can produce protein for humans more efficiently than crops could result in a reconceptualisation of livestock from being sources

of high-quality protein to being vehicles to use resources that cannot otherwise be used for food production (e.g., grasses and food by-products). Value chain developments will be important for both types of protein sources. New value chains will need to be developed for novel sources, but some restructuring of value chains for current sources will also be required. Stakeholders will be required to undertake roles in governance as well as in commercialisation to ensure that trade-offs are fairly accommodated and food security is ensured without compromising on sustainability. Multi-stakeholder action is required – highlighting the need for traditional actors in the supply chain to engage with NGOs and civil society actors, as well as policy makers.

Acknowledgements

This work forms part of the ReValueProtein Research Project (exploration of Irish meat processing streams for recovery of high-value protein-based ingredients for food and non-food uses; Grant Award No. 11/F/043) supported by the Department of Agriculture, Food and the Marine (DAFM) under the National Development Plan 2007-2013, funded by the Irish Government. Mark Fenelon, Anne Maria Mullen and Brijesh Tiwari, Teagasc Food Research Programme (Moorepark and Ashtown) also contributed to this work.

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Authors

Maeve Henchion

Head of Department of Agrifood Business and Spatial Analysis, Rural Economy and Development Programme, Teagasc, Ashtown, Dublin 15

Correspondence: maeve.henchion@teagasc.ie

Maria Hayes

Research Officer, Food Bioscience Department, Food Research Programme, Teagasc, Ashtown, Dublin 15



Uncovering obstacles to intergenerational farm transfer

This article looks at the micro-politics and managerial dynamics at play within farm households.



Joint farming ventures (JFVs), particularly farm partnerships, have been advocated within Irish farm transfer policy discourses as succession models that can enable young farmers to become formal partners in the family farm business, while also allowing the older generation to remain active and embedded in the farming community (Ingram and Kirwan, 2011; Conway *et al.*, 2016). While appreciating the merits of JFVs, the low levels of land mobility currently experienced in Ireland indicate that a clear disconnect exists between the younger generation's readiness to begin their career in farming, and their parents' lack of preparedness to hand over the farm.

The sheer number of family farms, their aggregate impact on the agri-food industry, and the potential economic and social losses that may occur as a consequence of this phenomenon, demand a deeper probing into the mindset and mannerism of older farmers, as these individuals ultimately have the authority to decide whether the transition of farm management and ownership takes place successfully or not.

Transferring the family farm clinics

In order to secure an in-depth understanding of the manner in which members of the senior generation maintain their authoritative position on farms, questionnaires were initially distributed to a randomly-selected

sample of farmers in attendance at a series of transferring the family farm clinics delivered by Teagasc in 2014 at 11 locations throughout Ireland. In order to deepen and build on the quantitative data gathered at the clinics, interviews were then conducted with a 10% sample of questionnaire respondents who gave their consent to be interviewed.

While appreciating the merits of JFVs, the low levels of land mobility currently experienced in Ireland indicate that a clear disconnect exists between the younger generation's readiness to begin their career in farming, and their parents' lack of preparedness to hand over the farm.

Generational shadow

Research findings indicate that the policy challenge to mobilise and support unconventional JFVs is not straightforward due to various defence mechanisms utilised by the older generation to avoid succession and deter it from occurring. Members of the senior generation were found to continually reiterate their indispensability to the daily management and operation of the farm, thus giving their dominant position within the farm household an entrenched legitimacy. This self-reinforcing aura of importance enables them to become the purveyors of beliefs, narratives and ideologies that a reduction in their involvement in farming, and particularly their retirement, would bring detrimental consequences onto their personal health and well-being. Empirical findings also highlighted the contradictory and conflicting desires of the senior generation. Even those in the process of, or who had already planned for, succession, resist 'fading into the background' and instead move to reassert their authority and centrality on the farm, thus forcing the younger generation to work under a generational 'shadow'. Take for example what Colm, a 71-year-old mixed livestock farmer from the south west of Ireland, said: "Even though most of the farm is now signed over to my son, in my head it's still mine, well while I am fit and able to do a bit around the place anyways. In fairness though, I've made sure that all the returns on the cattle and sheep and everything else are going into the farm account, which is now in his name, but at the same time, I stay in charge of that account, because I do the biro work you see – I sign the cheque books and that kind of stuff".

International best practice

While JFVs appear to tick all the boxes in relation to the ideal family farm transfer facilitation strategy, findings from this research indicate that they will be of little benefit if existing and future policy and schemes fail to consider methods of addressing the micro-politics and management power dynamics at play within farm households. A concerted effort is therefore required if the senior generation is to maintain normal day-to-day farming activity in later life, while also releasing the reins to allow for the delegation of managerial responsibilities and ownership of the farm to successors. If this fails to materialise, there will continue to be extraordinary socioeconomic challenges for younger people aspiring to pursue farming as a career. As every farmer and each family situation is unique, the full report on this study published in the *Journal of Rural Studies* (Conway *et al.*, 2017) acknowledges that while there are no easily-prescribed solutions to solving this complex challenge, the services of a certified farm succession facilitator, trained in accordance with an international best practice model such as the one offered by the International Farm Transition Network, is essential, particularly when facilitating discussions on family members' objectives, goals and expectations for the farm. There must be a seed that stimulates the need to act. Therefore, instead of facilitation being a voluntary service available to farmers, this study recommends that existing and future policies and programmes encouraging land mobility insist on a course of mandatory facilitation sessions with a farm succession

facilitator, ideally funded or subsidised by the Department of Agriculture, Food and the Marine (DAFM), in order to be eligible for financial incentives such as tax concessions. This would stimulate and encourage open lines of intergenerational communication within farm households, something that currently seems not to be the case. Such an implementation has the potential to greatly enhance the uptake and success of existing and future policy measures.

Acknowledgements

We are grateful to the farmers who took part in this research. Funding was provided by the National University of Ireland Galway Doctoral Research Scholarship Scheme. We would also like to thank Teagasc for assistance with this research, in particular for allowing us to conduct surveys with its farming clients.

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Authors

Shane Conway

PhD candidate, National University of Ireland Galway
Correspondence: s.conway9@nuigalway.ie

John McDonagh

Lecturer, Discipline of Geography, National University of Ireland Galway

Maura Farrell

Lecturer, Discipline of Geography, National University of Ireland Galway

Anne Kinsella

Senior Research Officer, Agricultural Economics and Farms Surveys Department, Rural Economy and Development Programme, Teagasc, Athenry, Co. Galway





New data for new policies

New farm sustainability indicators have been developed by **TEAGASC** researchers in collaboration with EU counterparts, as part of the EU-funded FLINT project.

A key question facing modern society is whether the agricultural sector can develop in a manner that is sustainable from economic, environmental and social perspectives (the three dimensions of sustainability). Population growth, climate change, energy, water supply and re-emerging diseases all affect the sustainable intensification (SI) of agricultural production across all three dimensions.

The objectives and evaluation needs of agricultural policies have evolved considerably since the MacSharry reform of 1992 to the current Common Agricultural Policy (CAP) and Rural Development Programme (RDP), which aim to ensure the sustainability of agriculture and rural areas. As policies change, so too do policy evaluation needs, requiring a broader set of reliable data to assess the impact of current and future policies against these sustainability objectives.

In this context, a multidisciplinary consortium of researchers from Ireland (Teagasc), the Netherlands, France, Greece, Hungary, Poland, Finland, Germany and Spain (Navarra region) came together to assess the feasibility of expanding the scope of data collected by the EU's Farm Accountancy Data Network (FADN) to better support policy analysis. The primary advantage of using FADN data lies in the harmonised and objective data collection system that operates across the EU and thus facilitates cross-country comparison.

The EU FP7 FLINT (Farm Level Indicators for New policy Topics) project devised a set of 33 'new' indicators, which could be used to assess the impact of policy on the economic, environmental and social sustainability performance of farms, using existing FADN data, and supplemented this with a pilot dataset of new indicators (collected on a sample of 1,100 farms across nine member states [MS] for 2015). The sustainability indicators developed were then used to demonstrate the usefulness of the additional data in effective policy analysis. Here we present examples of policy analyses achieved through the collection of this additional FLINT data.

Trade-offs

To better target and evaluate policies, there is a need for data that describe different aspects of environmental, economic and social sustainability on the same farm, and can detect trade-offs or 'jointness' between these aspects. Analysis of the FLINT data showed that economic and environmental sustainability can be positively correlated (for some farm systems and some environmental indicators).

For example, across all MS, crop farms that performed well economically also performed well environmentally. However, livestock farms that performed well economically tended to produce higher greenhouse gas emissions in absolute terms (per hectare) but often lower emissions on a per product basis, and had a larger nitrogen surplus per hectare. Across all farm types and MS, high economic performance tended to be associated with high social sustainability (Latruffe *et al.*, 2016).

Farm viability

Evaluation of CAP and RDP objectives to improve the viability of farms is challenged by: (a) the lack of data to benchmark the viability of farm households against non-farm households; and, (b) the lack of comparable data and measurement standards across the EU in relation to both farm and non-farm wage thresholds. In general, farms are deemed economically 'viable' if family farm income per labour input is greater than a threshold wage, whereas 'vulnerable' farms are not economically viable. In practice, many farms across the EU are reliant on off-farm income. The FLINT dataset contains new data on whether the farm household has off-farm income, allowing for the incorporation of a third 'sustainable' category (farms that are not viable but the farmer/spouse has off-farm income). Analysis undertaken by O'Donoghue *et al.* (2016) developed eight different models of viability to reflect the different calculation methodologies and thresholds employed in the surveyed

countries. The level and ranking of the indicators is sensitive to the measurement assumptions employed in the different models. **Figure 1** illustrates viability/vulnerability/sustainability indicators for six MS when farm viability is defined as: (family farm income – cost of own capital)/FWU (unpaid labour unit) $\geq$ paid wages.

Although Irish analysis has previously been undertaken using the Teagasc National Farm Survey (NFS), the combination of FLINT and FADN data makes it possible to conduct inter-country comparisons, which illustrate differences in farm and household viability across the EU. This analysis highlights the sensitivity of viability indicator results to measurement choices, which in turn raises the need for standardised data at EU level for future benchmarking of the viability of farms and farm households within wider society.

Extension use

The Teagasc NFS collects data on whether farms engage with extension services. However, FLINT provided additional data on the level of engagement and the type of services required, which shows that in Ireland, Spain and Poland, public extension services provide the most frequent interaction with farming households. In the Netherlands, Greece, Finland and Hungary, private advisory services are most commonly used, reflecting the different policy frameworks across Europe. More importantly from the perspective of policymakers, the analysis undertaken shows that there is a significant and positive difference in economic and social sustainability between users and non-users of extension services, and also between high and low users of extension services (Brennan *et al.*, 2016).

Summary

Policymakers need to evaluate the trade-offs between different policy objectives, e.g., farm income, different environmental impacts and food security (production levels). In addition, concepts like the bio-economy and circular economy will lead to new issues and indicators, while the issue of climate change – adaptation as well as mitigation – and the optimal use of natural resources will play a big role in post-2020 CAP policy evaluation. While the analysis presented here is limited by the pilot nature and sample size of the dataset, the FLINT project demonstrates that it is feasible to collect sustainability data within the FADN infrastructure and that policy evaluation in areas such as cross-compliance, greening, climate change, soil management, water, biodiversity, rural development/quality of life, and innovation can be improved with access to better data, while also providing sustainability credentials for the agri-food sector. The FLINT project also made recommendations on how to adapt the FADN system to support the ongoing need for the common monitoring and evaluation of future EU policies.

Acknowledgements

FLINT was funded under the EU 7th Framework programme. The authors acknowledge Brian Moran and the Teagasc NFS team, who collected and compiled the FLINT data, and Irish FLINT team members Emma Dillon (Teagasc) and Edel Kelly (University College Dublin). For further information on FLINT, see: <http://www.flint-fp7.eu/index.html>.

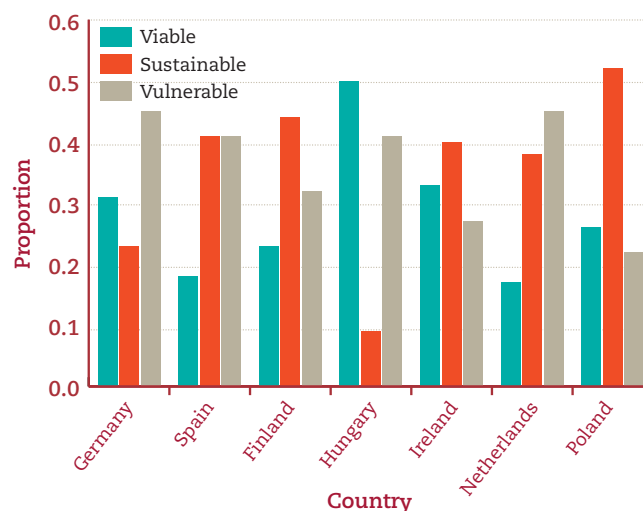


Figure 1: Viability categories across selected EU member states.

Related publications

- Brennan, N., Ryan, M., Cullen, P., Hennessy, T. and Dillon, E. (2016). 'Going beyond FADN: The use of additional data to gain insights into extension service use across European Union Member States'. *Studies in Agricultural Economics*, 118 (3): 145-153. Available at: <http://dx.doi.org/10.7896/j.1630>.
- O'Donoghue, C., Devisme, S., Ryan, M., Gillespie, P. and Conneely, R. (2016). 'Farm Economic Sustainability in the EU – A Pilot Study'. *Studies in Agricultural Economics*, 118 (3): 163-171. Available at: <https://ageconsearch.umn.edu/record/252985?ln=en>.
- Latruffe, L., Desjeux, Y., Hautravelo, G.J., Hennessy, T., Bockstaller, C., Dupraz, P. and Finn, J.A. (2016). 'Tradeoffs between Economic, Environmental and Social Sustainability: The Case of a Selection of European Farms'. Technical Report, 46 pages. Available at: <https://www.researchgate.net/publication/318361197>.

Authors

Mary Ryan

Agricultural Economics and Farm Surveys Department, Rural Economy and Development Programme, Teagasc, Athenry, Co. Galway
Correspondence: mary.ryan@teagasc.ie

John Finn

Soils, Environment and Land Use Department, Crops, Environment and Land Use Programme, Teagasc, Johnstown Castle, Co. Wexford

Thia Hennessy

Head of the Department of Food Business and Development and Chair of Agri-Food Economics, Cork University Business School



SEPTEMBER

September 7, 2.00pm Keadeen Hotel, Newbridge, Co. Kildare

NATIONAL CROPS FORUM

Organised by Teagasc tillage specialists, the Forum will look at the new varieties available this year and also at economic returns from the Teagasc e-Profit Monitor. There will also be a focus on issues around Brexit, the developing agricultural policy in both the UK and Europe, and the potential effects of changes on the tillage industry in Ireland.

www.teagasc.ie

Contact: michael.hennessy@teagasc.ie

September 25-26

Teagasc Ashtown, Dublin 15

XXXI EURAGRI CONFERENCE

This conference will address the different dimensions of research management in the context of an evolving European research agenda, focusing on the functions and challenges of research organisations concerning organisational and strategic management, including planning and implementation.

www.teagasc.ie/news--events/euragri-conference/

Contact: eilish.cray@teagasc.ie

OCTOBER

October 6

AFBI, Hillsborough, Co. Down

AVTRW ANNUAL SCIENTIFIC MEETING

The theme of the Association for Veterinary Teaching and Research Work's annual meeting is 'Emerging diseases – a focus on diagnosis'. The keynote speaker is Fredrik Granberg, Swedish University of Agricultural Sciences, who will present on the development and application of novel diagnostic methods, with a focus on novel nucleic acid amplification and sequence analysis technologies with associated bioinformatics. A number of Teagasc researchers will also be presenting.

Contact: kieran.meade@teagasc.ie

October 26

Teagasc, Ashtown, Dublin 15

A QUALITY EXPERIENCE: SENSORY EVALUATION IN FOOD QUALITY CONTROL

In an extremely competitive marketplace, manufacturing products of consistent sensory quality is essential for the food and beverage industry. The aim of this workshop, organised by Sensory Food Network Ireland, is to introduce delegates to sensory evaluation in quality control, and to demonstrate how sensory testing can assist companies in

delivering reliable products of consistently high quality to consumers. The workshop will include a combination of talks and practical exercises, with experienced speakers from industry and academia presenting.

www.sensoryfoodnetworkireland.ie Contact: lauren.mcmaster@teagasc.ie

NOVEMBER

November 9

RDS, Ballsbridge, Dublin 4

WALSH FELLOWSHIPS SEMINAR

The annual Walsh Fellowships seminar offers a unique opportunity for Walsh

Fellowship holders to present the results of their research to a wide and diverse public audience, including those involved in the agri-food sector, the third-level sector, policymakers, and research funding agencies. The seminar forms part of Teagasc's Science Week events.

www.teagasc.ie

Contact: hilary.king@teagasc.ie

November 12-19

Multiple locations nationwide

FESTIVAL OF FARMING AND FOOD – SCIENCE WEEK AT TEAGASC

Teagasc is holding a series of events for Science Week 2017. Many of Teagasc's research centres will open their doors for school visits, where students get to perform hands-on experiments and find out about careers in STEM. An event for the general public – '60 minute science' – will take place at the VISUAL Centre for Contemporary Art, Carlow, while at Teagasc Ashtown Food Research Centre Dublin, 'A Taste of Food Science' is open to the public. This festival is sponsored by Science Foundation Ireland.

www.scienceweek.ie

Contact: catriona.boyle@teagasc.ie



November 16

Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork

FOOD INNOVATION GATEWAYS – ADVANCED ANALYTICAL METHODOLOGIES FOR THE FOOD INDUSTRY

A range of technology offerings and services emanating from the Teagasc Food Research Programme will be on display. Presentations by national and international experts will outline the role of advanced analytical methods in guaranteeing the quality, safety and traceability of foods in compliance with legislation and consumer demands for a globally competitive Irish food industry.

www.teagasc.ie

Contact: gateways@teagasc.ie

November 28, 10am-4.30pm

Lyrath Estate Hotel, Kilkenny

November 29, 10am-4.30pm

Hotel Kilmore, Cavan

TEAGASC NATIONAL DAIRY CONFERENCE

Theme: 'Seizing opportunities for a better future'. The opportunity to increase farm profitability through growing milk production far outweighs the challenges faced by dairy farmers and the dairy industry. However, the opportunity will only be realised through the adoption of technologies and key management practices critical to sustainable milk production. This will become increasingly important as the scale of Irish dairy farms increases. This conference will focus on two key areas – grassland and people management. In addition, some of the more recent results from the comprehensive dairy research programme at Teagasc will be explored.

www.teagasc.ie/events Contact: niamh.allen@teagasc.ie

December 6-7

Teagasc Food Research Centre, Ashtown, Dublin 15

46TH ANNUAL FOOD SCIENCE AND TECHNOLOGY CONFERENCE

This event provides an opportunity for early career researchers to present their research. The main themes of the event are: advances in food chemistry and technology; food processing and technology; innovations; food safety and quality; and, nutrition and healthy ingredients. This Institute of Food Science and Technology of Ireland event is chaired by Brijesh Tiwari, Teagasc.

www.teagasc.ie

Contact: brijesh.tiwari@teagasc.ie

For a full list of Teagasc food industry training events see: www.teagasc.ie/food/food-industry-development

For presentations from previous Teagasc events see: www.teagasc.ie/publications